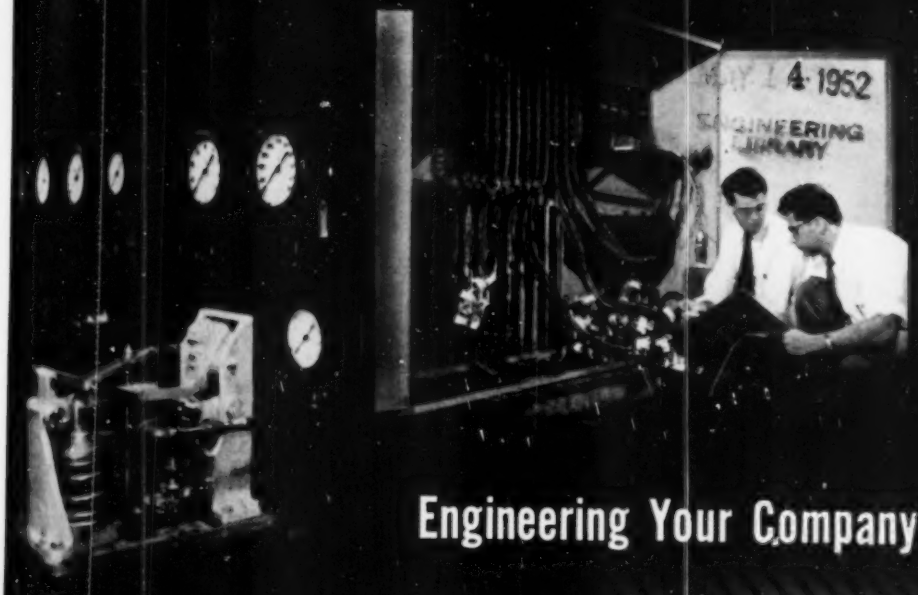
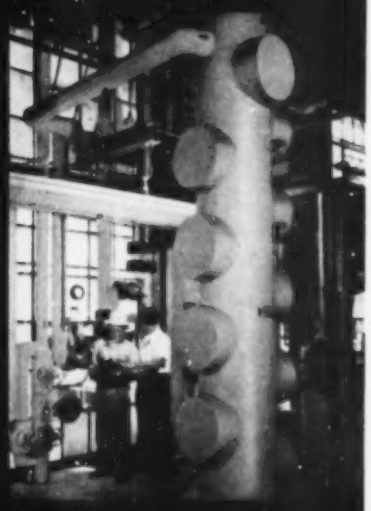
# PRODUCT ENGINEERING

MAY 1952



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VOLUME 23 — PRODUCT ENGINEERING — NUMBER 5

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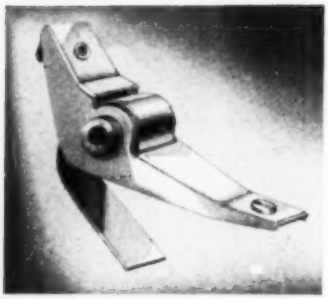
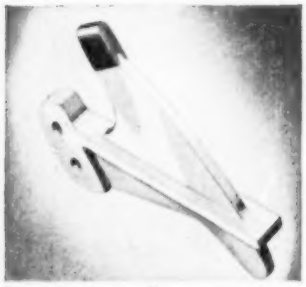
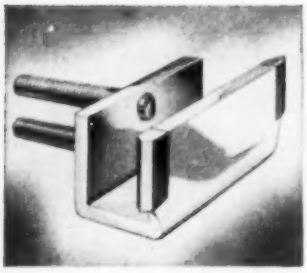
# Don't let contact assembly problems "sidetrack" your engineers... your production facilities!







No manufacturer today can afford to waste either man hours or machine time. He must plan his operations so that both work full time at the jobs they can do best—their regular jobs.

You can avoid diverting men and machines from your own specialty by turning to Mallory for improved design and the production of contact assemblies—a job for which Mallory has the necessary specialized skills, materials and tools.

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Call or write Mallory today. You'll find, as many other manufacturers have, that it really pays in many ways to count on Mallory for all your contact assembly needs.

●● *Shown here are examples of Mallory contact assembly design and production. Each represents a practical, economical answer to specific problems of conductivity . . . necessary physical strength . . . secure bonding of contact to backing material. You can count on the same kind of satisfactory answer to all your contact assembly problems when you put Mallory's specialized knowledge, techniques and materials to work for you.*

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# Highlights

When requesting further information from companies and organizations mentioned in the items below, confusion can be avoided by referring to the issue of Product Engineering in which items appear

## METALLIC MATERIALS

**CREEP STUDIES** recently completed at the Bureau of Standards on copper, cold-drawn to 40 percent reduction in area, reveal its fracture resistance to be markedly superior to that of the annealed material. This superiority in strength is accompanied by considerable loss in elongation at fracture. For equivalent second-stage creep rates and temperatures, reduction of area at fracture is about same for both forms of copper.

**LOW-ALLOY STEELS** originally developed for high temperature applications have been modified for use at 1,100 F. Minimum rupture strength is 30,000 psi for 1,000 hr at high stress. Tests at Timken Roller Bearing Co. show pre-normalizing at high temperature does not increase strength at 1,100 F, but it does up the strength of the 12-Cr stainless grades.

**THE RARER METALS** like tantalum, columbium, zirconium and titanium cannot be furnaced and cast according to standard procedures because they attract oxygen and nitrogen, and form irreversible oxides and nitrides. Inert gas atmospheres and high vacuum methods are generally the answer, according to Process Chemical Specialties Co. of Beverly, Massachusetts.

**GREATER TWO-TONE GLAMOUR** for polychrome or metallic finishes is possible when Alcoa's tinting paste No. 222 is used. It does not interfere with true color values while achieving a high degree of iridescence. Intended primarily for automotive finishes, the paste also imparts a striking, beautiful effect to the hammer-tone finish on household equipment and appliances.

**ONE OF THE LARGEST** tin bronze castings ever made is a 20,000-lb pump casing recently cast by Baldwin-Lima-Hamilton Corp. at Eddystone, Pa. Alloy used contained 8.0 percent tin and 2.0 lead. Manganese bronze is generally used.

**SEMI-CONDUCTORS** composed of germanium alloyed with nitrogen, copper, silver, magnesium, titanium or uranium recently brought U.S. Patent 2,588,253 to Purdue University Research Foundation. Materials can be used in contact-type rectifiers that withstand high operation voltages, have low forward and high back resistance, and do not require power for heating a cathode.

**IRON SILICON SHEET** for use as 4-mil laminations in high frequency inductors was developed primarily for the 400 to 2,000 cycle range, but is adaptable to the audio range. Thomas and Skinner Steel Products Co. of Indianapolis reports the OrthoSil material has ultra-high permeabilities and low core losses when used in transformers, saturable reactors and filters.

## NONMETALLIC MATERIALS

**AN ADDITIVE** that improves the ignition qualities of diesel fuel is the brain-child of researchers at the Ethyl Corp. As little as 0.01 percent by volume of the DB-36 amyl nitrate improver is enough to raise the centane number of distillate heating oils within range of diesel fuels.

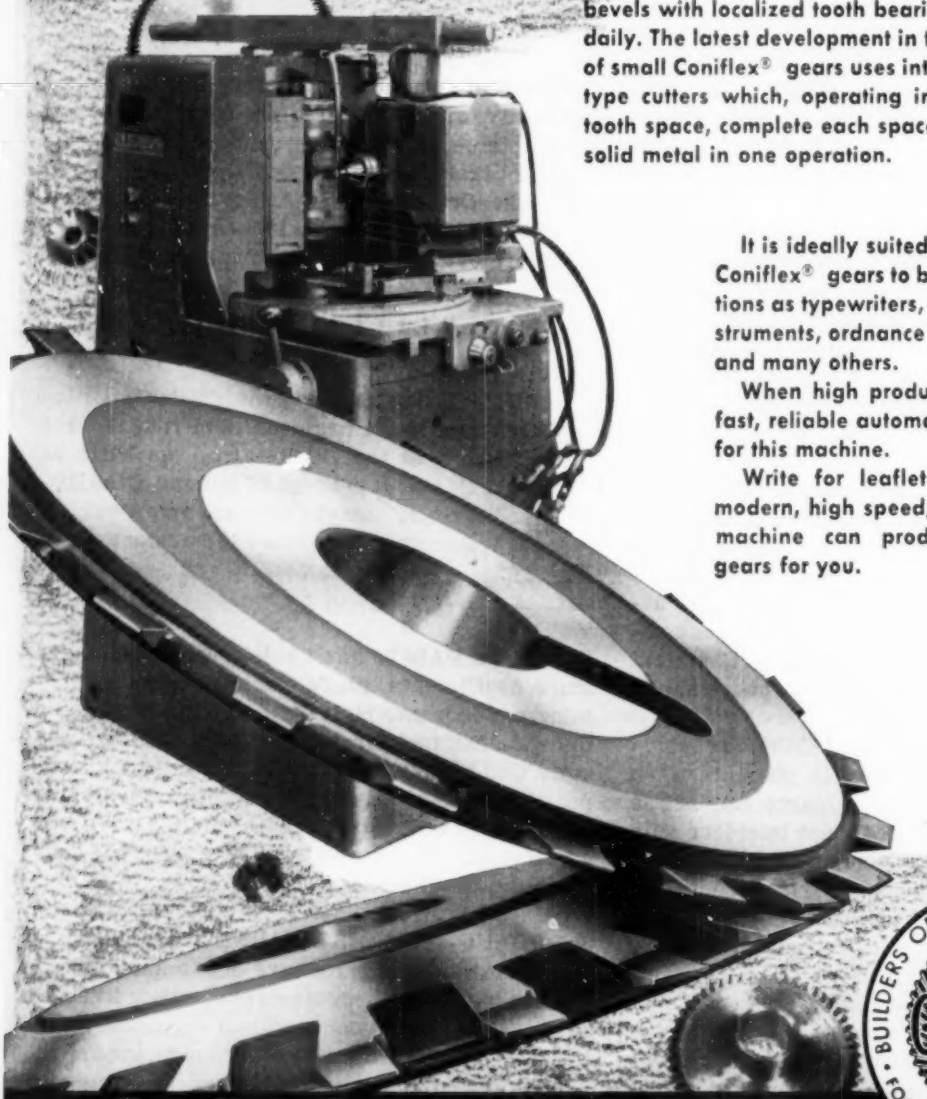
**RESISTOR PAINTS** having high negative temperature coefficients can be used as contacts, terminals, condenser plates and shields when fired to heat-resistant ceramic surfaces. Micro-Circuits Co. of New Buffalo, Mich. vary the composition of their silver Micropaint to give electrical characteristics required for a given application. Firing temperature is 1,100 to 1,300 F; firing time, seven to ten minutes.

**A RUBBER-PHENOLIC VARNISH** announced by GE permits the manufacture of laminated plastics having two to three times the impact strength of those made with conventional varnishes. The #12359 material is flexible yet tough and is expected to find application in gears, shuttles and castor wheels. The new product may also mean the entry of phenolics into the paper-coating field.

*(continued on page 7)*

# THOUSANDS OF SMALL CONIFLEX® GEARS ARE CUT DAILY

**With the new Gleason No. 2 Straight Bevel Generator thousands of small size straight bevels with localized tooth bearing are cut daily. The latest development in the cutting of small Coniflex® gears uses interlocking-type cutters which, operating in a single tooth space, complete each space from the solid metal in one operation.**



**It is ideally suited to the manufacture of Coniflex® gears to be used in such applications as typewriters, business machines, instruments, ordnance equipment, hand tools and many others.**

**When high productivity is the object, a fast, reliable automatic loader is available for this machine.**

**Write for leaflet describing how this modern, high speed, completely automatic machine can produce small Coniflex® gears for you.**

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**GLEASON WORKS**

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HEAT AND ARC RESISTANCE of Fiberglas-reinforced polyester laminates made by Glastic Corp. of Cleveland was basis for inexpensive redesign of a solenoid switch. With laminated phenolic parts, switch was rated at 25 a, a-c; with the polyester, capacity is 50 a, d-c. Glastic sheets come in thicknesses up to 1 1/8 inches.

HEATING TAPE developed by Electrofilm Corp. of N. Hollywood, Calif. consists of heater elements that can be wrapped around cylinders and tubes to provide warmth up to 300 F. Rated at 2.5 w per sq. in., the tape has a one-inch-wide heating surface centered on a 1 1/2-in.-wide band.

A TROPICAL HARD WOOD that is half as strong as aluminum, yet only one third as heavy, has been found in Central America by a professor at the Yale School of Forestry. The Kaneelhart wood can be machined to a mirror-like finish.

## COMPONENTS

COPPER-LEAD BEARINGS containing 40 percent lead are suitable for use on unhardened steel shafts (Brinell 180-200) and therefore possible as bearing materials on slow-speed diesels or gas engines. Fatigue life of such bearings is more than twice that of babbitt. 2,500 psi is considered maximum permissible load.

WEIGHING HALF AS MUCH as present motors, but having equivalent power, new fractional horsepower design perfected by GE makes metals allotments go twice as far. Feature of new motor is an instalation system containing nylon, said to be one of first uses in mass-produced motors.

ELECTRON DEFLECTING SYSTEM which simplifies television tube construction was described at New York meeting of the Institute of Radio Engineers. Consisting of interleaved metallic patterns deposited on the inside of a hollow rectangular box by photo-engraving and electroplating, unit has only four terminals and does same job as conventional deflecting elements.

HYDRAULIC CONTROL CIRCUITS are easily modernized with Armortube cable. Bailey Meter Co. of Cleveland assembles bundles of aluminum or copper tubing and encases them in a galvanized steel tube. Purpose is to avoid the confusion of running many separate pressure lines.

MORE THREADS take the load in a new locknut designed by Klincher Locknut Corp. of Indianapolis. Grooved washer pressed over thin-walled threaded base of nut moves axially and radially when being tightened. This action locks nut and effectively forces bulk of load up into body of nut.

INSTRUMENT RECTIFIERS made up of selenium rectifier cells are reported to have higher blocking and lower conducting resistance than conventional units. Spokesman for Electronic Devices, Inc., 12th St., Brooklyn, N.Y., states that uniformity within and between the assemblies is the result of matching the characteristics of individual cells. A special plate stabilizing process also contributes to the efficient operation of the rectifier assembly.

ELECTRIC WRIST WATCH was recently demonstrated by the Elgin National Watch Co. "Power plant" that energizes tiny motor for turning the hands through a train of gears is a capsule battery half an inch long and smaller around than a pencil. The "tickless" watch runs accurately for a year on a single battery, say the makers.

## PROCESSES

HOT-DIPPED aluminum coatings can be applied to steel strip at rate of 10 to 50 ft per min if anti-oxidation techniques are used. Prefluxing with alkali metal chlorides is one method, pre-treatment in a reducing atmosphere in conjunction with a fluxing process is a second. Pre-coatings of tin, zinc or cadmium give inconsistent results.

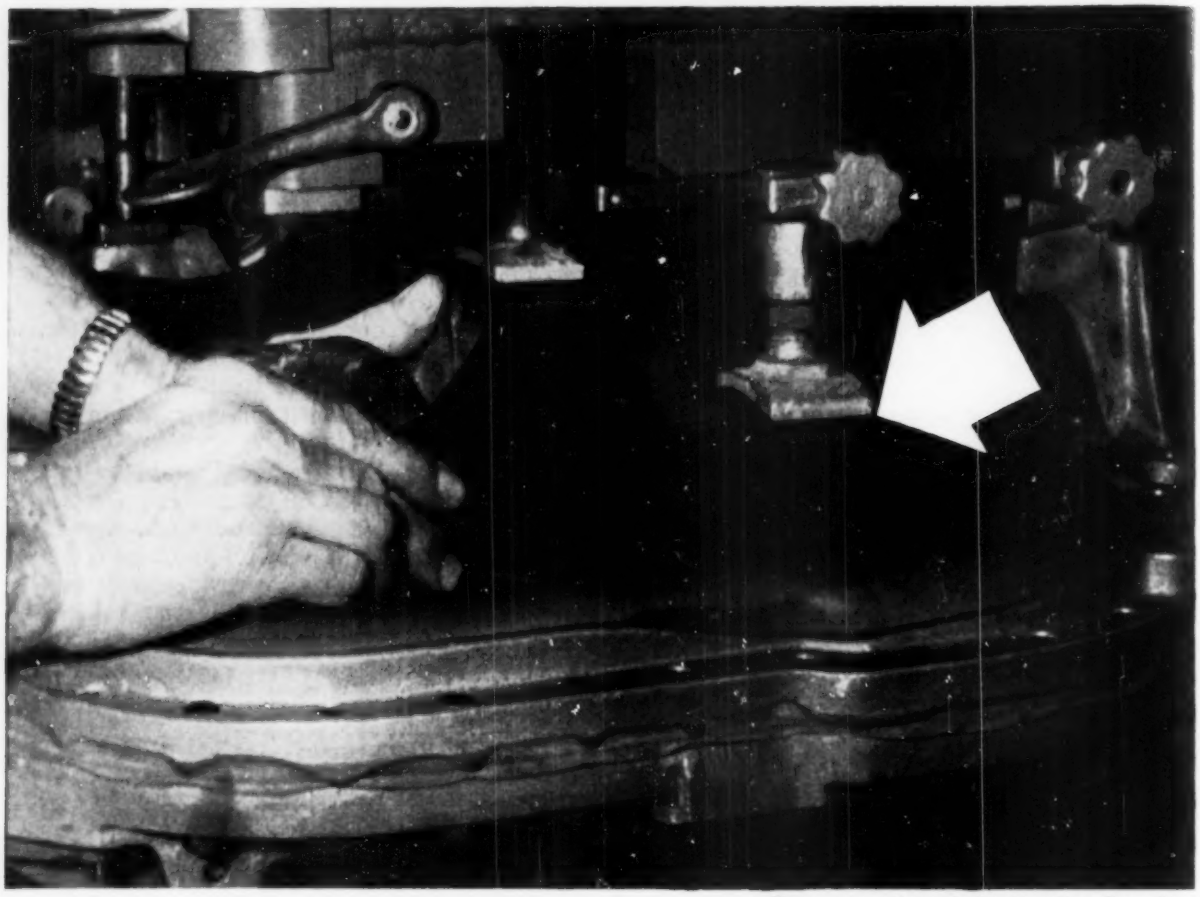
PRESS FORGING of structural panels for aircraft from aluminum alloys such as 75S and 14S and Dow FS magnesium alloy is a recently perfected technique at Lockheed. Pieces thinner than 0.09 in. with little or no draft angle have been made. Thicknesses of 0.45 to 0.5 in. and as much as 70° draft are typical for drop forgings.

CONTROL AGENTS improve the strength and fatigue resistance of lead-tin platings used on batteries, chemical containers and plain bearings. The Johnson Bronze Co. of Newcastle, Pa. finds a little gelatin or glue produces fine-grained deposits and resorcinal inhibits changes in plating composition. A small amount of copper, arsenic or antimony also increases strength.

*(continued on page 9)*

***Another new development using***

# B. F. Goodrich Chemical *raw materials*



*Data courtesy of Compo Shoe Machinery Corp., Boston, Mass.*

## Doesn't tread on toes but wears well for years!

THE "toe rubber" pictured here helps thousands of shoes get a good start in life—helps the shoe manufacturer cut costs, too. It's an iron arm, capped with a Hycar rubber-phenolic compound. The cap rests on the toe of the shoe, holds it in place while a platform is attached to the sole.

Most important—the toe rubber must not scratch or mar the leather. Yet it must have good abrasion resistance for long service to keep production going without costly interruptions.

That's just where Hycar fills the bill perfectly. The cap surface is so smooth that it won't mar the finest leather. Yet it is so abrasion-resistant that it lasts for several years. Compare that service with a standard rubber cap—which lasts less than two months!

Hycar-phenolic compounds have many advantages that help designers and molders in many cost-saving ways. They impart extra toughness and shock-resistance to molded parts. In processing, they provide better molding characteristics . . . easier flow in the mold than straight phenolics . . . resistance to cracking around metal inserts in the part.

A Hycar rubber compound may help you improve a product or solve a problem. For versatile Hycar is used as a base material . . . as a modifier for phenolic resins . . . as an adhesive base . . . as a latex for coating or impregnating. For technical bulletins and advice, please write Dept. HP-3, B. F. Goodrich Chemical Company, Rose Building, Cleveland 15, Ohio. In Canada: Kitchener, Ontario. Cable address: Goodchemco.

**B. F. Goodrich Chemical Company**
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**Hycar**
Reg. U. S. Pat. Off.
*American Rubber*

**GEON polyvinyl materials • HYCAR American rubber • GOOD-RITE chemicals and plasticizers • HARMON organic colors**

GALVANIZED ANGLE IRON can be welded with a gas shielded torch and Everdur filler rod without appreciable damage to zinc coating. Slight reduction in coating thickness occurs next to weld as result of vaporization under heat of the arc.

HIGH CURRENT DENSITIES distinguish the Hardas anodizing process from standard techniques. Hard Aluminum Surfaces Ltd. of Glasgow, Scotland produces hard layers up to 0.010 in. thick, claim they will scratch glass, and adhere well, especially to aluminum alloys containing magnesium. Treatment improves the life of rotor and side plates of pumps, and turbine blades.

PITTING AND CORROSION of airplane propellers is reduced by a hard, yet resilient, plated-nickel coating. Key to technique worked out by Bart Labs of Belleville, N. J. and United Aircraft's Hamilton Standard Div. is a synthetic rubber compound sprayed on the aluminum blades. Once rubber is dry, nickel is plated on the stress-free surface in conventional manner.

## TESTING

"CURVED LIGHT" is used to find faulty combustion and flame leakage in GE jet aircraft engines. One end of a curved quartz rod is located inside combustion area to be checked. Light from jet's flame travels back through rod to instruments that convert the light into measurable units.

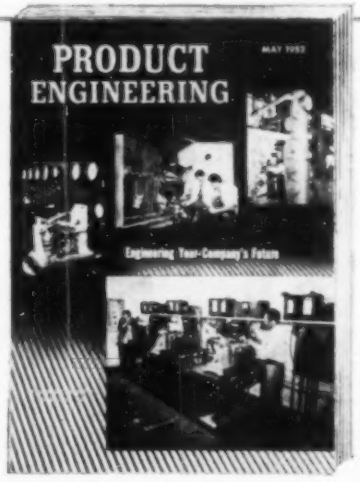
FAST-ACTING THERMOMETERS consisting of white pigment films on black paper indicate a temperature in range from 115 to 500 F. When film melts, it disappears into the porous paper.

COMPACT COUNTER, the Geiger Mite, weighs less than half a pound, including headphones; is only one inch in diameter and 4 in. long. Made by Morgan Instruments Co., 21420 Valero St., Canoza Park, Calif., device has no battery because it is self-charging. Power is supplied by a built-in electrostatic generator that becomes charged after being shaken about 20 times.

MULTIPLE-CHANNEL MANOMETER providing high-accuracy results at all the currently usable Mach numbers is now in operation at the Naval Ordnance Laboratory's Supersonic Wind Tunnel at White Oak, Md. Equipment has made it possible to take pressure distribution measurements on a "production basis" at Mach 4.28 and 5.18 on guided missile models. Built-in automatic control and photographic registration make it easy for two persons to operate the equipment.

FLYING TYPEWRITER prints a line at a time instead of a single character. Officials of the Potter Instrument Co. of Great Neck, L.I., N.Y. say the machine handles 300 lines of 80 alphanumeric characters per minute; can be used as a digital computer. It's also adaptable to data on coded information transmitted by radio link or telephone and telegraph lines as well as serial coded information on magnetic tape.

WHILE INVESTIGATING how atomic hydrogen is transmitted through some metals, a scientist at the state University in Madison, Wisconsin made a palladium metal tube the cathode in an ordinary sulfuric acid electrolytic bath. He found that hydrogen passed through the metal at ordinary room temperature, and built up a pressure of 700 pounds per square inch.




### THIS MONTH'S COVER

Perhaps the most difficult job facing the engineering executive today is that of organizing and operating his department efficiently and of establishing proper channels to management for the interchange of planning objectives. Particularly is this difficult when there is a myriad of engineering operations in several divisions and plants, as indicated on the cover by photographs from the General Electric Company. Top right, distillation column for silicone manufacture; top center, checking layout of temperature recorder stand for gas turbine testing; left center, testing vacuum trip cut-out for steam turbine governor; bottom, fatigue testing of specimens for gas turbine buckets.

The answers to many of these organizational problems and planning techniques can be found in the special section, "Engineering Your Company's Future," which starts on page 151.

# IF you want the last word on Eddy-Current Couplings, write for your copy of this booklet

Eddy-Current Couplings provide a long list of desirable characteristics including instantaneous response, infinitely adjustable speed control, wide speed range, quiet operation, low power losses, low maintenance cost—without mechanical contact between the driving and driven members—and entirely from AC power.

If you are interested in this modern method of speed control, write on your company stationery for this comprehensive booklet. It presents a down-to-earth explanation of the Eddy-Current Principle, and the operation of the Dynamatic Eddy-Current Water-Cooled Coupling.

DYNAMATIC® CORPORATION • KENOSHA WISCONSIN

*Subsidiary of* EATON MANUFACTURING COMPANY, Cleveland, Ohio

Dynamometers • Oil Well Draw-Works Brakes • Adjustable-Speed Couplings • Eddy-Current Brakes
Ajusta-Spedes • Shovel Clutches • Press Drives • Lift Truck Clutches • Electronic Controls

# Perspectives — DESIGN AND DEVELOPMENT

GOVERNMENT RUBBER

Government monoply of the synthetic rubber industry has been continued again for another two years. At one point before Korea, there was a chance that the plants might be sold to private industry. But with the outbreak of another national emergency, all such prospects went by the board.

Congressional committees in charge of rubber legislation are putting military security first. And at this time there is no disposition to rock the boat by turning the industry back to private hands, a problem which is extremely complex, and politically potent.

Government operation of the plants is universally felt to be bad on philosophical grounds. But practically, it continues to be a happier solution than figuring out how to turn the plants loose.

For one thing, Government operation assures continued production of synthetic, the consideration which has top priority. Congressmen aren't sure what might happen if synthetic is turned back to private competition.

Another point is that rubber fabricators now all get an even break on supply and price of synthetic, something that is absolutely necessary, since the $700-million industry was developed with the taxpayers' money.

Right now, synthetic production is rolling at a high rate and meeting all requirements. In fact, the Government is building inventories.

Leland Spencer, rubber boss of Reconstruction Finance Corp., told a Congressional committee recently these high points of the rubber situation:

1. Controls on all but butyl may soon be dropped completely.
2. Cold rubber production will continue to constitute a greater percent of total synthetic production. Cold rubber will be 60 percent of the total in the third quarter of 1952; to be 70 percent during the fourth quarter and 75 percent during the first quarter of 1953.
3. It is very doubtful that synthetic rubber can now replace natural in all uses.
4. Consumption of synthetic should not be allowed to drop below a point where all of our petroleum butadiene plants are in operation. (Alcohol-for-rubber plants are more expensive, marginal producers of rubber raw material.) That would mean continuing synthetic rubber production at around 600,000 or 650,000 tons per year.

ASTIA

The Defense Department has set up the Armed Forces Technical Information Agency to centralize the publication and distribution of research reports prepared by all the Armed Services. ASTIA is being organized under the immediate direction of the Secretary of the Air Force.

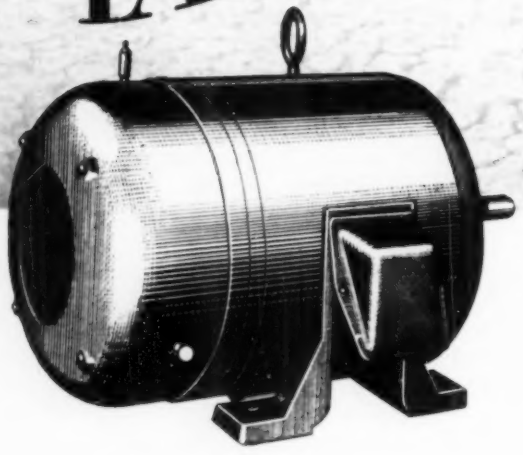
When ASTIA gets in high gear this is how it will work. Reports written by or for any defense department agency will be immediately forwarded to ASTIA. They will edit and publish the report in a standard form. At the same time, they will apply the proper security classification. Then they will distribute it to other government agencies and to industrial and university organization that need the information to augment their own work. Distribution will be in line with the new policy of "Tell them only what they need to know."

*(Continued on page 115)*

# ELECTRO DYNAMIC

INDUSTRIAL MOTORS

## Toughened to "TAKE IT"



EBCo-built *U.S.S. Perch* in maneuvers off Alaska. Official U.S. Navy photo.

To withstand the terrific strains of submarine service, Electro Dynamic motors have long featured *extra-dependable* performance and *extra-rugged* construction to resist stress and prevent twisting and distortion.

E. D. motors for industry, like their famous marine counterparts, are built to stand up under the hardest kinds of uses. Their husky cast frames and housings assure rigidity and resist corrosion. And the special care and superior insulating materials that go into the WINDINGS . . . "the heart of the motor" . . . provide many extra years of dependable, low-cost operation.

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In the near future, every company working on a Defense Department contract will receive an extensive questionnaire listing over 400 fields of interest. After the company has indicated which of these they are working in, the Defense Contracting Officer will review the form and pass it on to ASTIA with his recommendations. Distribution of information will be based on this questionnaire.

Standardization of reports can save considerable time and money. It also may help plug some of the leaks through which Defense Department new developments have been slipping. Unfortunately, it puts ASTIA in a position to exert complete censorship on technical information if they so desire and the agency's powers will have to be used wisely.

ASTIA's first official act (other than organization work) indicates what can happen when this agency is misused. They classified as restricted the Technical Data Digest prepared by the Central Documents Office of the Army, Navy, and Air Force. Formerly widely circulated to universities, research organizations, and industrial companies, this publication prints abstracts of technical articles that have appeared in the business press, house organs, and association journals. No reason was given for the classification.

**METALS EASING**

NPA plans to boost metals inventory limitations from 45 days to 60 days as a result of softening in the supply picture, which shapes up like this:

Steel: Industry-wide troubles interfered with a general softening of conditions. When difficulties started in April, supplies in general were easing. Sheet was plentiful, while plates and structural shapes were much tighter. Warehouses supplying less than carload lots were well fixed.

Aluminum: Improved supply is prompting NPA to consider removal of aluminum from control of packaging enclosures. Estimated aluminum production for the second quarter is 640 million lb, same as for the first. Production of 710 million lb is expected in the third quarter; and 740 million lb in the fourth.

Nickel: Continues to be in very short supply.

Tin: Controls will be necessary for some time, even though the situation is improving as a result of government purchase agreements with several countries, particularly Britain and Indonesia.

Lead: Supplies good, and controls have been virtually relaxed.

Zinc: Supplies much better than previously. World market will shortly be stabilized as it has for lead. IMC allocations on zinc for the second quarter are 22,495 tons above previous quarter.

Copper: IMC's second quarter allocations are 21,000 tons below the previous quarter's. Domestically refined copper supply reached a new low during April. And the supply is likely to be on a touch-and-go basis for several months. NPA is trying to stimulate the flow of scrap to custom smelters as a means of increasing the refined copper supply.

Ferrochromium: U. S. Supplies in 1952 will be bigger than in 1951. 890,000 tons of chromite suitable for metallurgical use will be shipped here; about 200,000 tons above last year's imports.

**HARD GOODS**

Consumer goods manufacturers are over the hump on materials shortages. They'll get bigger government allotments from here on out. Big question now is: can they sell all they can make? Controls officials insist that lack of consumer demand helped as much as materials restrictions to cut first quarter production. Post-Korean panic buying is blamed for depressing hard goods sales. And many consumers loaded themselves down with installment payments. Some Government economists think that durable goods sales will start climbing soon. They estimate that most consumers have paid off their last installments on their late 1950 buying spree and are ready for more heavy buying.

# PUSH-ON SPEED NUTS®

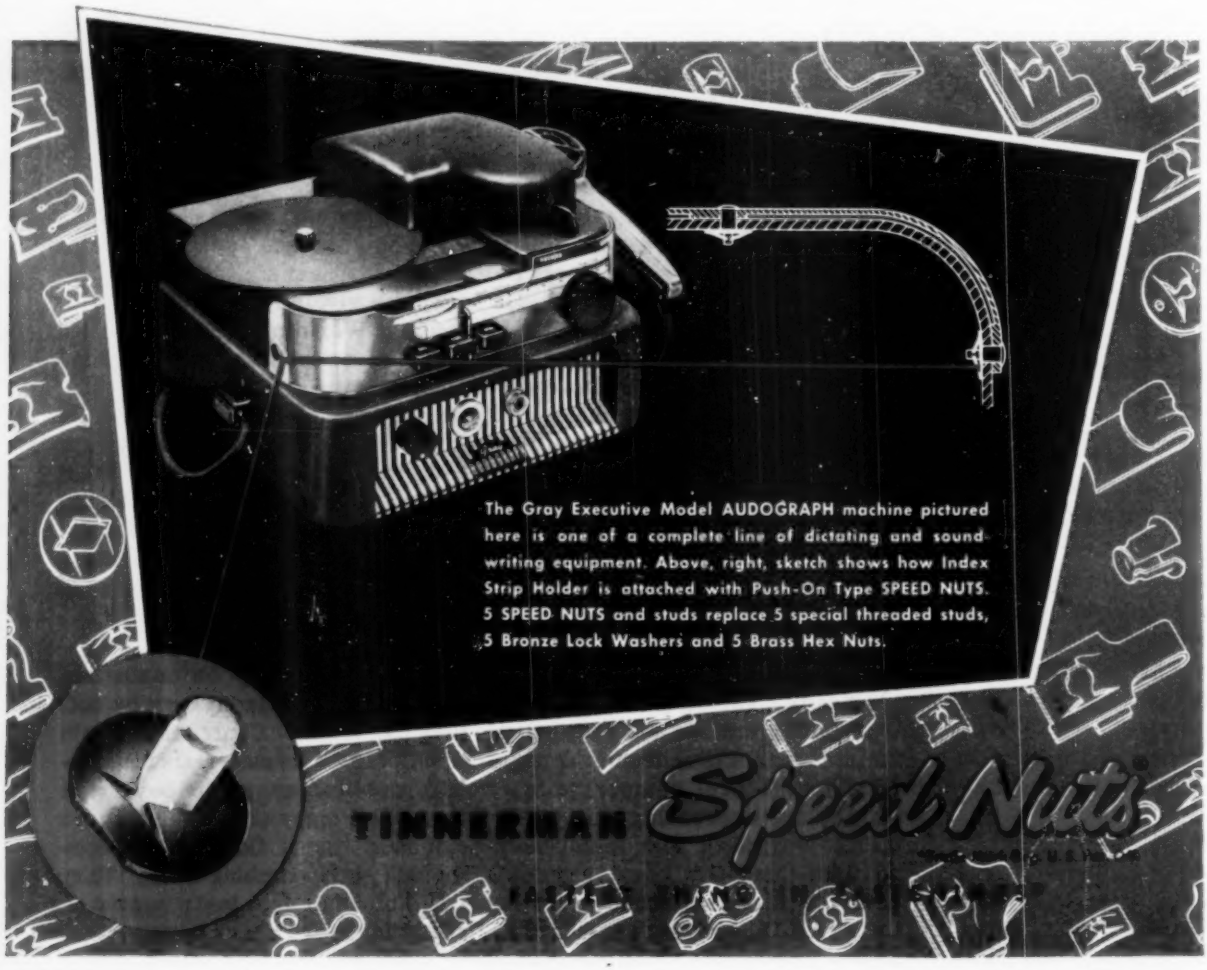
## *Make New Record*

## FOR GRAY AUDOGRAPH

**Here's how SPEED NUTS made a 50% savings in time, and a 75% material savings in the assembly of Gray AUDOGRAPH Dictating Machines . . .**

Engineers at Gray Manufacturing Company took a second look at the index strip on their Audograph Machine and this is what they found. Five standard Tinnerman Push-On Type SPEED NUTS could be zipped over plain studs to attach the complete Index Strip Holder Assembly in half the time . . . replacing hex nuts, lock washers and eliminating special threaded studs.

This is just one of the many SPEED NUT Savings Stories being reported every day in a wide variety of industries. Take a second look at some of your assembly operations with an eye to keeping costs down and quality production UP; your Tinnerman representative is prepared to help. SPEED NUTS are the most economical fasteners ever developed—to prove the point, we'd like to make a comprehensive Fastening Analysis of your product line. In the meantime, write for your copy of SPEED NUT Savings Stories, TINNERMAN PRODUCTS, INC., Box 6688, Cleveland 1, Ohio. *In Canada:* Dominion Fasteners, Ltd., Hamilton. *In Great Britain:* Simmonds Aerocessories, Ltd., Treforest, Wales. *In France:* Aerocessoires Simmonds, S. A.—7 rue Henri Barbusse, Levallois (Seine) France.


The Gray Executive Model AUDOGRAPH machine pictured here is one of a complete line of dictating and sound-writing equipment. Above, right, sketch shows how Index Strip Holder is attached with Push-On Type SPEED NUTS. 5 SPEED NUTS and studs replace 5 special threaded studs, 5 Bronze Lock Washers and 5 Brass Hex Nuts.
TINNERMAN
Speed Nuts®

# Supply and Demand Can Do It Better

THERE ARE ALWAYS MEN vainly attempting to invent perpetual motion. There are also many others who subconsciously believe that they have the power to peer behind the curtain that veils the future. And there are legions who attempt by edict to circumvent the natural law of supply and demand or improve upon it. To succeed they would have to have a power greater than nature. They fail miserably but magnify every modicum of success.

Admittedly, some controls are sometimes necessary. But when man attempts artificial controls that are expected to operate superior to natural controls in the allocation of materials, he sticks his neck out. Merely because a man has been elected or appointed to a public office does not give him the super-human power which would be required to allocate the use of materials to the best advantage.

There are those who will point to the wonderful governmental materials controls exercised during World War II. How efficient were they? Who can tell how much worse, or better, it would have been if certain of those controls had not existed. Today we again have materials controls and again they are creating confusion and resulting in serious consequences.

Secondary aluminum was selling for 32½ cents per pound. The Office of Price Control ordered a price reduction of 12 cents to 20½ cents per pound. At about the same time the office of Price Control ordered that the price of prime zinc be increased from 17½ cents to 19½ cents per pound. The idea was to increase the use of more abundant aluminum and ease the short supply of zinc. Before the bureaucrats knew what was happening, zinc was in vast oversupply.

It takes weeks or months before the bureaucrats get around to rectifying their errors. They seldom admit them; they always explain them away. What takes them weeks or months to do, Old Man Law of Supply and Demand will do overnight or even faster.

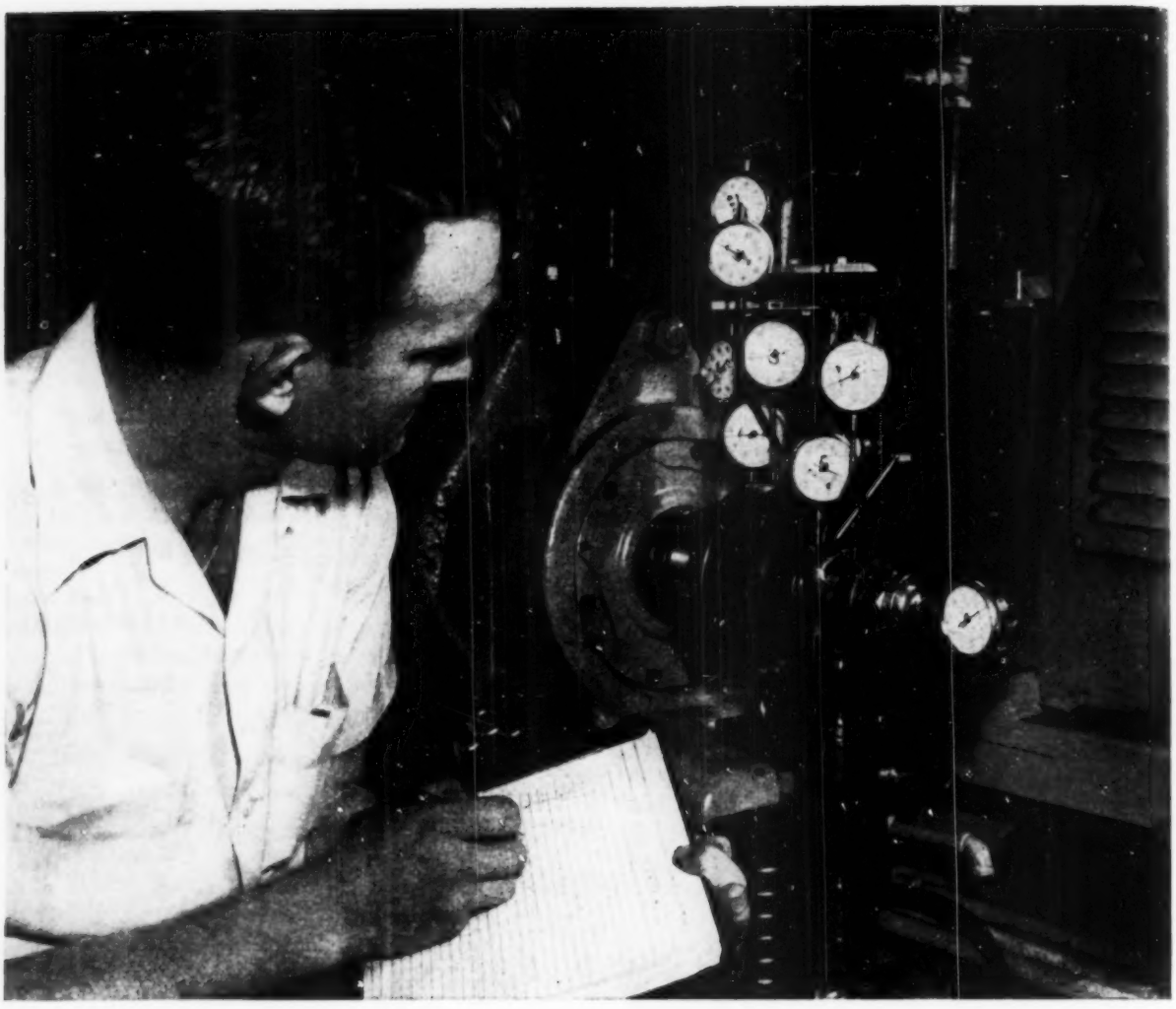
The above is only one example. Steel, which was heralded to be of precious metal scarcity, is now in good supply. Nickel, which was hailed to be among the scarcest of metals, is now quite readily obtainable. Tin, copper, aluminum and most other materials are likewise in much greater supply.

In the meantime design engineers are being forced to look for substitutes again and again. Production schedules of civilian goods are being needlessly disrupted. The "materials' scarcity" picture changes radically overnight. Old Man Supply and Demand must be having a good laugh watching puny humans who believe that the sceptre of authority makes them more powerful than he.

For more than three decades we have seen controls follow controls and fiasco follow fiasco. Controls addicts picture dire results that would have occurred had it not been for controls. But they cannot prove it. Nor can anyone prove the opposite—other than to point out that much confusion and dishonesty always accompanies controls.

Regardless of arguments pro and con, the established fact is that the present materials' controls are simply not working and are hampering production needleesly. It is getting more obvious daily that it would have been far better to let Old Man Supply and Demand have things his way. It certainly would have saved a lot of design headaches.

G. F. Nordenholt



# Theories proved or exploded here

• Before you place a new design on the market, it is important that you know how it will work under operating conditions.

Where the design involves the use of anti-friction bearings, New Departure's new, ultra modern testing laboratory can determine *in advance* what performance you can expect "in the field".

Furthermore, as the study progresses, New Departure engineers may find it possible to improve the performance or the assurance of success by applying their ingenuity and their fund of knowledge and over forty years experience to the subject at hand.

May we work with you on your anti-friction problems?

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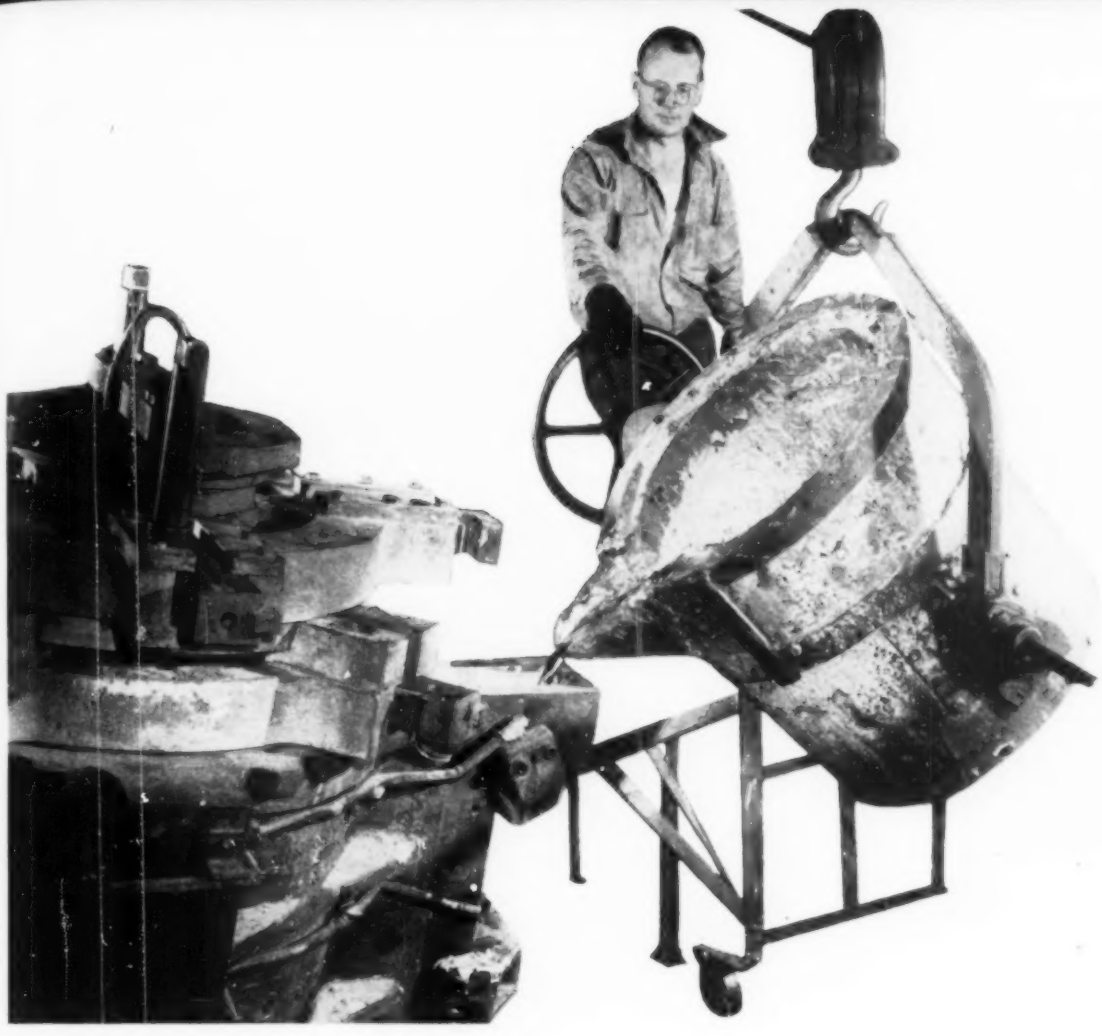

# Fatigue Properties of Cast Aluminum Alloys

**Heat-treatments resulting in lower ductilities and higher ratios of yield-to-tensile strength appear to have beneficial effects on the notch-sensitivity of alloys.**


R. L. TEMPLIN
Assistant Director of Research and Chief Engineer of Tests

F. M. HOWELL
Chief, Mechanical Testing Division

J. O. LYST
Research Engineer
Aluminum Company of America


WHEN CAST ALUMINUM ALLOY PARTS are designed for service in automobile engines, railway coaches and airplanes where stress loads are repetitive, the engineer's thoughts naturally gravitate to the fatigue strength of the materials involved. But extensive tests on 28 alloys that were cast in sand molds and 17 alloys that were cast in permanent molds reveal there are no pronounced differences in the fatigue strengths of the various materials. As a result, greater attention can be given when selecting an alloy to other factors such as static strength, castability, machinability, corrosion resistance and cost.

The size of Table I (page 122), which lists the nominal compositions and tensile properties for fatigue test conditions, attests to the exhaustiveness of the investigation. Some of the alloys were tested as sand castings, some as permanent mold castings and several as both types of castings. The wide ranges of tensile properties resulting from heat-treatment are particularly noteworthy, and, as will be shown, these differences in static property values are not reflected in the

fatigue strengths of the alloys.

The tensile property data given were all obtained in accordance with ASTM Standard methods. The values given are representative and typical of the alloys in the various conditions indicated when cast in the size and form of standard tension test bars, nominally ½-in. in dia at the test section. Castings having sections departing appreciably from this size would be expected to show differences in their static mechanical properties from those given for the tensile test specimens. Some of the alloys included in Table I are not currently available commercially, but were offered to the trade at various times during the past twenty-five years. The data for these "obsolete" alloys do serve to further exemplify some of the conclusions reached and therefore justify their inclusion.

### Test Procedure

Fatigue data for the cast aluminum alloys were obtained from tests of smooth R. R. Moore type of rotating-beam fatigue specimens as shown at the top in Fig. 1(a). Similarly the notch fatigue data were obtained from specimens having the dimensions shown in Fig. 1(b). Both types of specimen were machined from standard cast tension test bars. The maximum stresses in the notched specimens were computed assuming a uniform test section having a diameter corresponding to the diameter at the root of the notch. In both instances, the nominal stresses vary from some value in tension to an equal value in compression during each test cycle. At right ends of scatter bands in Fig. 1, the data points shown with a line through them represent specimens that did not fail.

### Sand Cast Alloys

In presenting the fatigue data, the results from all the sand cast alloys in all tempers, using the smooth or unnotched specimen, are shown in Fig. 1(a). The data are based on nearly 800 tests of 55 different alloys and tempers and include 93 separate lots of specimens. The limits of the scatter band for the data have been drawn so as to include essentially all the results obtained. The notched specimen data are similarly shown in Fig. 1(b). Results from 500 tests represent 45 different alloys and tempers and 66 different lots of specimens.

Scatter bands of the type in Fig. 1 appear in some of the subsequent illustrations for the purpose of evaluating the effects of various heat treatments. The bands are also useful in comparing results from specific lots of specimens

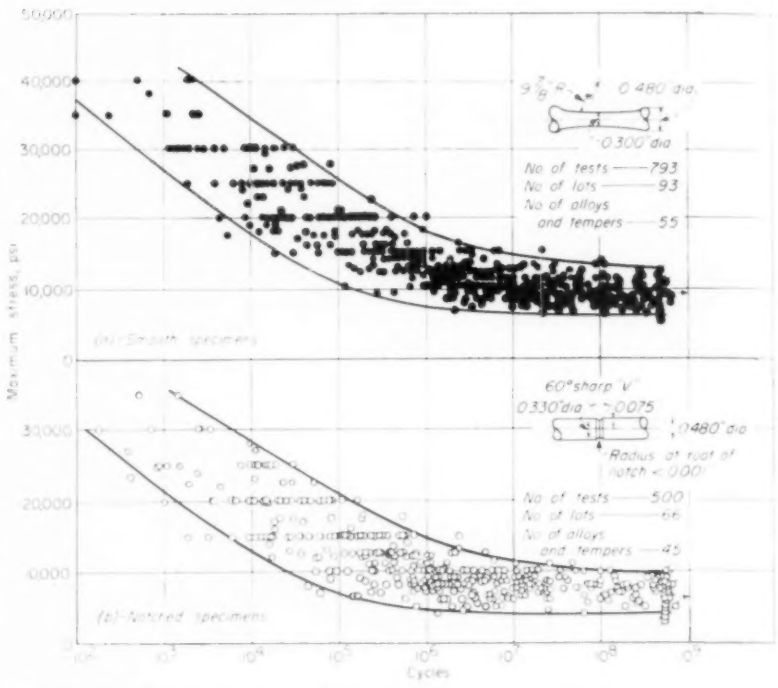


Fig. 1—Scatter bands show range of fatigue strengths for sand cast alloys.

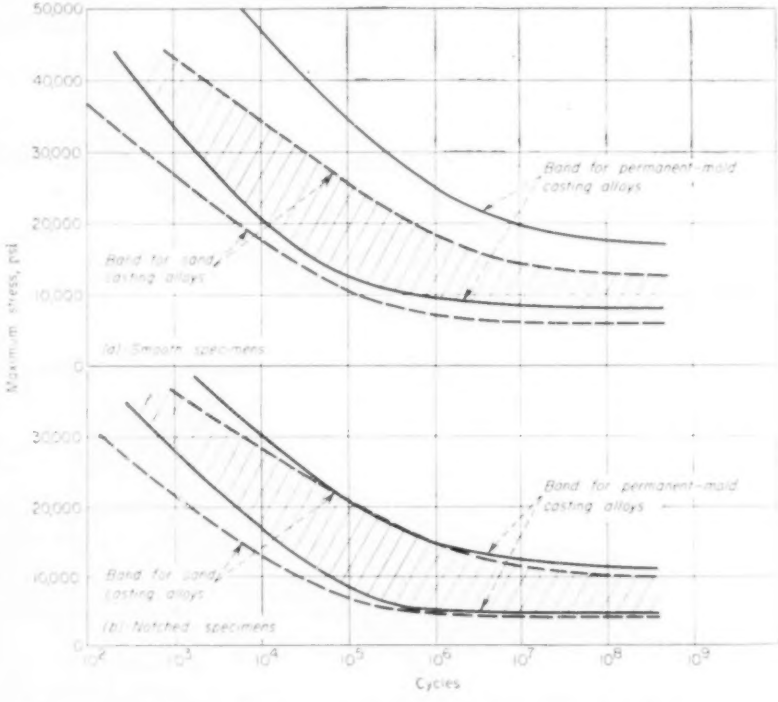


Fig. 3—Comparison of scatter bands for sand cast and permanent mold alloys.

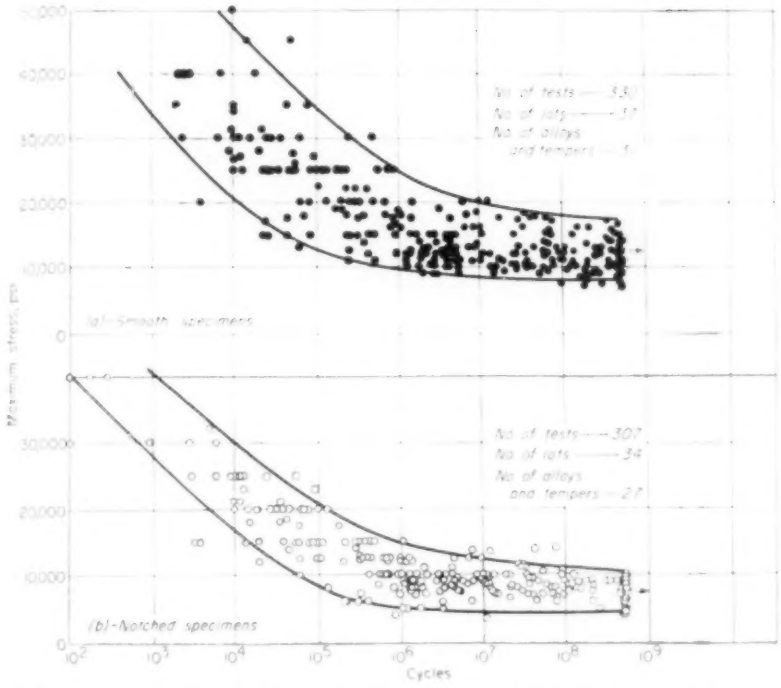
No. of tests — 330
No. of lots — 17
No. of alloys and tempers — 5
(a)-Smooth specimens
No. of tests — 307
No. of lots — 34
No. of alloys and tempers — 27
(b)-Notched specimens
Maximum stress, psi
Cycles

Fig. 2—Permanent mold alloys lose 35 percent of fatigue strength when notched.

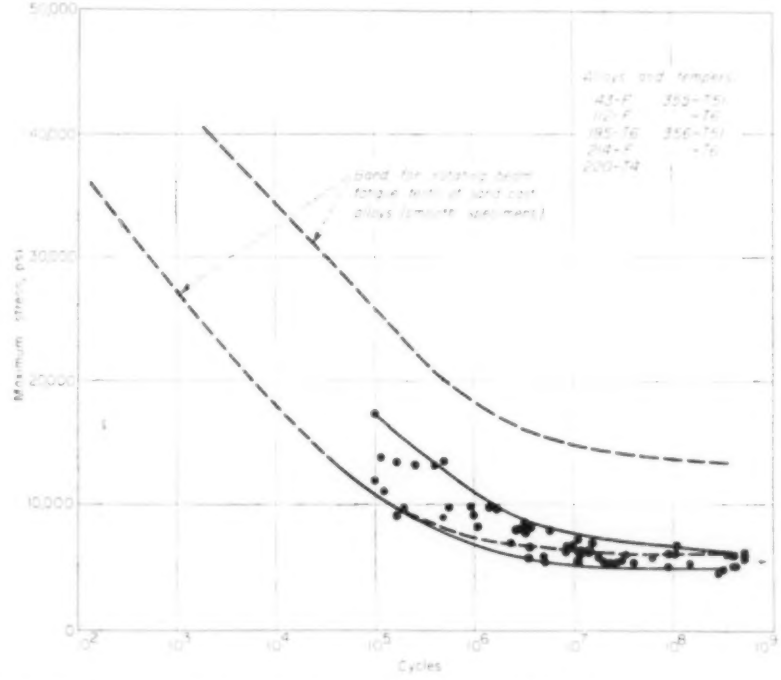


Fig. 4—Axial stress fatigue data for sand cast alloys exhibit little scatter.

of a given alloy and treatment, tests from various laboratories and data obtained from different kinds of testing machines.

Considering the diversity in the compositions of the alloys tested, the absence of significant differences in fatigue strengths is surprising. The general observation is that differences attributable to chemical composition throughout the ranges covered are not much greater and frequently less than those resulting from slight variations in specimens and testing conditions.

The fatigue strengths of the different alloys, in general, vary throughout the ranges shown in Fig. 1, irrespective of the tensile strengths of the individual alloys and particularly at the larger numbers of cycles. In this connection, it should be borne in mind that this type of test makes it difficult to obtain satisfactory values for stresses above the yield strength.

The results obtained from these tests of notched specimens indicate the sharp notch causes an average reduction in fatigue strengths of about 25 percent throughout the range of alloys and tempers considered. The presence of the sharp external notch also tends to decrease the scatter of results slightly but not significantly. The —T4 and —T6 heat treatments seem to improve the fatigue strengths slightly when using both the smooth and notched specimens, these effects being more pronounced for the higher stresses and lower numbers of cycles. The —T6 treatment, which decreases the static tensile elongations appreciably, apparently does not increase the notch-sensitivity of the materials.

### Permanent-Mold Cast Alloys

Results from the fatigue tests of the permanent mold aluminum alloys are also shown as composite plots in Fig. 2. The external sharp notch reduces the fatigue strength of these alloys about 35 percent and heat treatment causes no clearly defined benefits in fatigue strength.

To facilitate a comparison of the sand and permanent mold cast aluminum alloys, the scatter bands for each group are superimposed in Fig. 3. The "smooth specimens" bands, Fig. 3(a), show the permanent mold alloys have somewhat higher fatigue strengths throughout the full range of cycles. Since there is considerable overlapping of the bands, the differences noted may not be of practical significance in designing parts made from these aluminum alloys. The superimposed bands for the notched specimens, Fig. 3(b), are essentially the same for the sand and permanent mold alloys, with perhaps slight differences in favor of the

## Table I—Nominal Composition and Tensile Properties of Aluminum Casting Alloys

| Alloy and Temper | Alloying Elements, percent | | | | | | Sand Casting Alloys | | | Permanent Mold Casting Alloys | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cu | Si | Mg | Zn | Ni | Other | Tensile Strength, psi | Yield Strength, psi (0.2% offset) | Elong, percent in 2 in. | Tensile Strength, psi | Yield Strength, psi (0.2% offset) | Elong, percent in 2 in. |
| 12-F[1] | 8 0 | — | — | — | — | — | 26,100 | 15,500 | 2 0 | — | — | — |
| 43-F | — | 5 0 | — | — | — | — | 19,600 | 8,200 | 7 0 | 22,300 | 7,600 | 13 0 |
| 45-F | — | 10 0 | — | — | — | — | 18,700 | 8,800 | 4 0 | 32,400 | 12,800 | 9 5 |
| 108-F | 4 0 | 3 0 | — | — | — | — | 25,900 | 19,100 | 1 0 | — | — | — |
| 109-F | 12 0 | — | — | — | — | — | 26,400 | 18,800 | 0 8 | — | — | — |
| 112-F | 7 0 | — | — | 1 7 | — | — | 25,100 | 21,000 | 0 9 | — | — | — |
| -T2 | | | | | | | 22,200 | 15,800 | 1 0 | — | — | — |
| 113-F | 7 0 | 2 0 | — | 1 7 | — | — | 28,000 | 24,500 | 1 0 | — | — | — |
| B113-T6 | 7 5 | 1 5 | — | — | — | 1 2 Fe | — | — | — | 42,600 | 33,200 | 2 2 |
| C113-F | 7 0 | 3 5 | — | — | — | — | — | — | — | 31,600 | 27,100 | 0 8 |
| -T2 | | | | | | | — | — | — | 24,800 | 13,100 | 1 8 |
| L-1-F | 12 0 | — | | | — | 1 0 Mn | 22,200 | — | 0 7 | — | — | — |
| 122-F | 10 0 | — | 0 2 | — | — | — | 29,900 | [2] | 0 8 | | | |
| -T2 | | | | | | | 22,500 | 18,000 | 0 8 | | | |
| -T551 | | | | | | | — | — | — | 36,800 | — | 0 0 |
| -T65 | | | | | | | — | — | — | 49,600 | 49,500 | 0 8 |
| 132-F | 0 9 | 14 0 | 1 0 | — | 2 5 | 1 0 Fe | — | — | — | 35,600 | 29,300 | 1 0 |
| -T7 | | | | | | | — | — | — | 38,800 | 38,700 | 0 8 |
| A132-T551 | 0 8 | 12 0 | 1 2 | — | 2 5 | — | — | — | — | 35,900 | 24,900 | 1 0 |
| D132-T5 | 3 5 | 9 0 | 0 8 | — | 2 5 | — | — | — | — | 31,900 | 24,100 | 0 9 |
| 142-F | 4 0 | — | 1 5 | — | 2 0 | — | 29,800 | [2] | 0 5 | — | — | — |
| -T2 | | | | | | | 25,100 | 20,300 | 0 8 | — | — | — |
| -T21 | | | | | | | 27,000 | 18,400 | 1 3 | — | — | — |
| -T571 | | | | | | | 35,800 | 34,200 | 0 5 | — | — | — |
| -T61 | | | | | | | 41,900 | [2] | 0 3 | 41,500 | 36,300 | 1 0 |
| -T77 | | | | | | | 28,700 | 21,700 | 1 5 | 52,000 | 45,800 | 1 4 |
| A142-T75 | 4 0 | — | 1 5 | — | 2 0 | 0 2 Cr | 32,800 | 25,300 | 1 3 | — | — | — |
| 151-F | 5 5 | — | — | — | — | 1 0 Sn | 39,200 | 31,500 | 2 8 | — | — | — |
| 195-T4 | 4 5 | 0 8 | — | — | — | — | 37,400 | 27,300 | 5 5 | — | — | — |
| -T59 | | | | | | | 20,800 | 13,200 | 2 0 | — | — | — |
| -T61 | | | | | | | 37,300 | 25,600 | 3 9 | — | — | — |
| -T62 | | | | | | | 44,300 | 37,200 | 2 3 | — | — | — |
| A195-T4 | 4 5 | — | — | — | — | — | 38,900 | 24,900 | 7 8 | — | — | — |
| B195-T4 | 4 5 | 2 5 | — | — | — | — | 39,300 | 28,000 | 6 0 | 43,400 | 24,000 | 9 0 |
| -T6 | | | | | | | — | — | — | 50,400 | 33,600 | 5 6 |
| 196-T62 | 4 0 | — | 0 2 | — | — | — | 48,600 | 26,000 | 0 5 | — | — | — |
| 214-F | — | — | 3 8 | — | — | — | 27,300 | 11,800 | 12 6 | 25,400 | 12,500 | 8 5 |
| B214-F | — | 1 8 | 3 8 | — | — | — | 22,100 | 13,100 | 2 5 | — | — | — |
| 220-T4 | — | — | 10 0 | — | — | — | 42,200 | 26,900 | 10 4 | — | — | — |
| 319-F | 3 5 | 6 3 | — | — | — | — | 27,100 | 19,500 | 1 0 | — | — | — |
| -T21 | | | | | | | 22,700 | 11,900 | 1 5 | — | — | — |
| -T4 | | | | | | | 37,100 | 30,600 | 1 3 | — | — | — |
| -T72 | | | | | | | 32,400 | 23,000 | 1 4 | — | — | — |
| 333-F | 3 8 | 9 0 | — | — | — | — | — | — | — | 34,500 | 20,600 | 1 5 |
| -T5 | | | | | | | — | — | — | 31,100 | 19,300 | 1 5 |
| -T6 | | | | | | | — | — | — | 49,500 | 35,500 | 3 0 |
| -T7 | | | | | | | — | — | — | 38,600 | 26,100 | 2 0 |
| A334-F | 3 0 | 4 0 | 0 3 | — | — | — | 25,300 | 21,500 | 1 0 | — | — | — |
| 355-T4 | 1 3 | 5 0 | 0 5 | — | — | — | 30,000 | 23,000 | 1 8 | 39,700 | 24,200 | 6 0 |
| -T51 | | | | | | | 27,000 | 22,500 | 1 3 | — | — | — |
| -T514 | | | | | | | 26,400 | 21,500 | 1 5 | — | — | — |
| -T6 | | | | | | | 38,200 | 27,400 | 3 5 | 41,600 | 30,800 | 3 9 |
| -T61 | | | | | | | 41,200 | 33,100 | 3 0 | — | — | — |
| -T62 | | | | | | | — | — | — | 46,900 | 41,800 | 2 0 |
| -T7 | | | | | | | 37,400 | 32,900 | 1 5 | — | — | — |
| -T71 | | | | | | | — | — | — | 39,600 | 32,000 | 3 0 |
| A355-T51 | 1 4 | 5 0 | 0 5 | — | 0 8 | 0 8 Mn | 26,400 | 21,800 | 1 0 | — | — | — |
| -T59 | | | | | | | 26,300 | 20,700 | 1 0 | — | — | — |
| -T6 | | | | | | | 35,600 | 28,800 | 1 7 | — | — | — |
| -T71 | | | | | | | 37,500 | 33,000 | 2 2 | — | — | — |
| B355-T6 | 1 2 | 5 0 | 0 5 | — | — | 0 15 Cr | 31,800 | 25,400 | 2 8 | — | — | — |
| 356-T4 | — | 7 0 | 0 3 | — | — | — | 30,200 | 18,000 | 5 8 | — | — | — |
| -T51 | | | | | | | 29,000 | 22,700 | 2 4 | — | — | — |
| -T59 | | | | | | | 25,100 | 18,600 | 2 5 | — | — | — |
| -T6 | | | | | | | 31,800 | 23,800 | 4 0 | 41,600 | 30,100 | 8 0 |
| -T7 | | | | | | | 33,800 | 29,100 | 3 0 | 30,600 | 22,400 | 12 5 |
| -T71 | | | | | | | 29,500 | 22,800 | 3 5 | — | — | — |
| 406-F | — | — | — | — | — | 2 0 Mn | 17,600 | 8,800 | 10 2 | — | — | — |
| A612-T5 | 0 5 | — | 0 7 | 6 5 | — | — | 38,400 | 30,500 | 4 0 | — | — | — |
| C612-F | 0 5 | — | 0 35 | 6 5 | — | — | — | — | — | 32,400 | 16,000 | 9 0 |
| 645-F | 2 7 | — | — | 10 5 | — | 1 2 Fe | 38,700 | 31,800 | 1 3 | — | — | — |
| 750-F | 1 0 | — | — | — | 1 0 | 6 5 Sn | — | — | — | 21,200 | 7,200 | 14 8 |
| -T6 | | | | | | | — | — | — | 23,700 | 9,900 | 11 8 |

[1] Temper designations: F—As cast; T2—Annealed; T4—Solution heat treated; T5—Artificially aged only; T6—Solution heat treated and artificially aged; T7—Solution heat treated and stabilized.

[2] Yield strength practically equal to tensile strength.

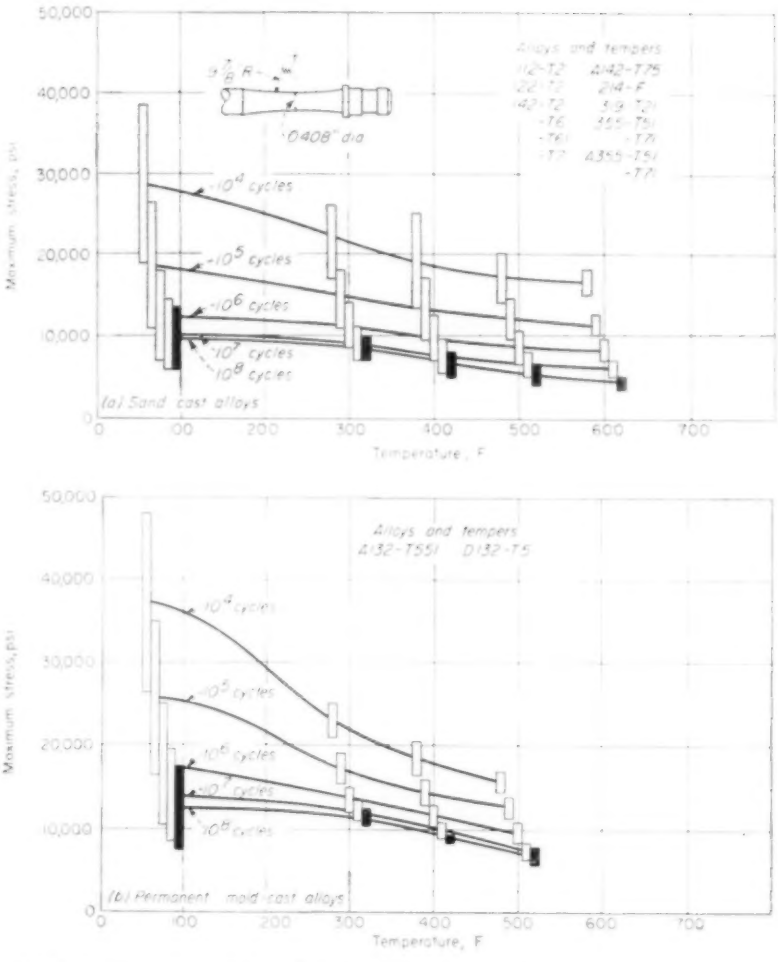


Fig. 5—Cantilever beam fatigue data for cast alloys at elevated temperatures.

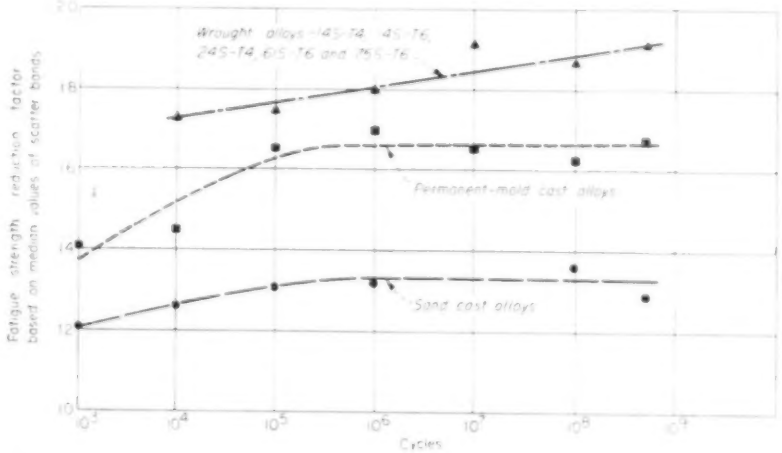


Fig. 6—Comparison of notch sensitivity for aluminum alloys in various forms.

permanent mold alloys indicated for the higher stresses.

Different types of fatigue tests produce differences in numerical results for a given material. Because some axial-load (reversed-stress) fatigue data are available for some of the sand cast aluminum alloys tested, they are presented in Fig. 4, along with the corresponding band from the rotating-beam type of test data. The direct-stress data exhibit definitely less scatter than the beam type, and, at the same time, somewhat lower numerical values, as would be expected from other investigational work. Unfortunately, direct-stress tests of severely notched specimens involve many unsolved testing difficulties that are quite conducive to both scatter and low values for maximum stress.

### Temperature Effects

In general, higher temperatures affect adversely the fatigue strengths of the cast aluminum alloys. Although the available test data are not as comprehensive as those taken at room temperature, there are enough to indicate the effects of temperature on the fatigue strengths of some of the alloys in both the sand and permanent mold conditions. These data are shown in Figs. 5(a)&(b). Both the ranges and the averages of the fatigue strengths are shown for various temperatures from room to 600 F, based on various lives or numbers of cycles ranging from $10^4$ to $10^8$. Smooth specimens were used throughout this series of tests.

At the higher temperatures, the differences in fatigue strengths between the various aluminum alloys become less and, in many instances, are of no significance from the engineering design viewpoint. Slight differences in favor of the permanent mold alloys are indicated and may be of interest in some applications.

An attempt has been made in Fig. 6 to show a comparison of the notch-sensitivity of the various cast aluminum alloys, as well as a comparison of these materials with the wrought aluminum alloys. The fatigue-strength-reduction factor used in this plot is the ratio of the fatigue strengths of smooth specimens to those of the notched specimens. In general, the cast alloys appear less notch-sensitive than the wrought alloys, as would be expected. Similarly, the permanent mold alloys are somewhat more notch-sensitive than the sand cast alloys and appear to be nearer the wrought than to the sand cast alloys. And, finally, there seems to be less change in notch-sensitivity with stress level or life for the cast alloys than for the wrought materials.

# Designing for Less Friction

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Bendix Aviation Corporation

THE EFFECTS OF FRICTION in mechanical mechanisms range from functional inaccuracy to increased power requirements and distortion of members by loadings more severe than were expected. Yet, in many cases, friction is not even considered when such elements are designed. In other cases, the design could be substantially improved by a better understanding of the effect of design proportions on friction forces.

A feel for good design from a friction standpoint can be developed. In general, this feel involves three considerations:

(1) Have sliding surfaces carry as little normal load as is practical.

(2) Design for a minimum amount of rubbing motion at normally loaded sliding surfaces so the driving force has a maximum amount of leverage to overcome the friction loads.

(3) Use flexible type members in place of sliding ones. This involves introducing a spring rate effect which often is small enough to neglect. However this approach is restricted to applications that have limited working strokes.

The following examples illustrate the application of these considerations to several widely used elements and point out some of the effects of friction that are easily overlooked in practice. However, their use is intended only where it is consistent with the other design requirements. Although the use of anti-friction bearings is a valuable asset, the very advantages of these bearings may tempt the designer to ignore the possibilities of carefully designed plain bearings and flexible members as considered on the following pages.

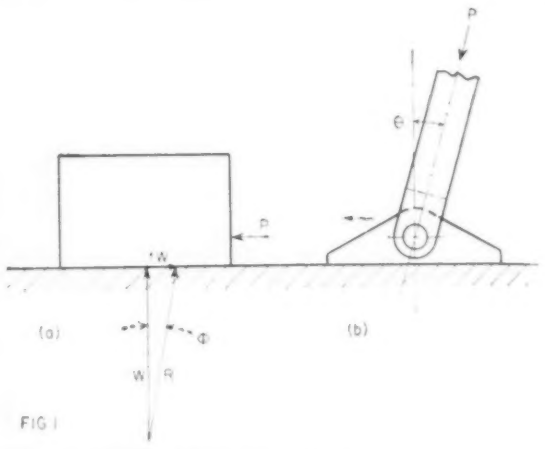

FIG 1

PLAIN SLIDING FRICTION (Fig. 1) For uniform motion of the block shown in (a), the applied force $P$ must equal the resisting frictional force $fW$. For continuous sliding, the coefficient of friction $f$ varies from about 0.05, steel on bronze with oil or graphite lubrication, to approximately 0.25, steel on steel without lubrication. Vibration can reduce this coefficient to zero, and is sometimes used for this purpose.

The resultant force $R$ makes an angle $\phi$, called the friction angle, with the normal force $W$. For $f$ of 0.15, $\phi$ is about $8\frac{1}{2}$ degrees. The importance of this angle

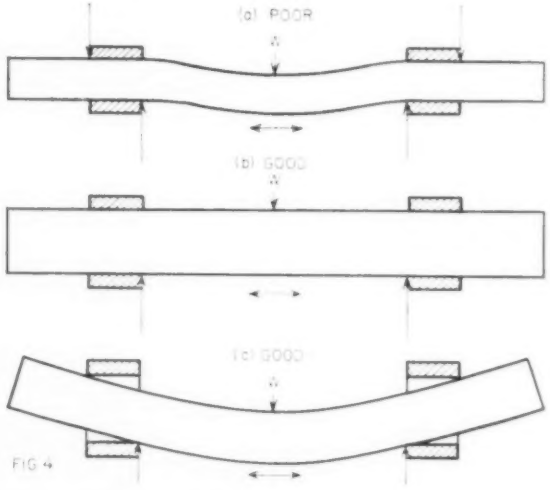

FIG 4

SHAFT DEFLECTION (Fig. 4) Shaft deflection in (a) causes the bearings to carry more radial load than they would for a rigid shaft. The resulting condition is similar to that of two overhung shafts, as in Fig 2, connected at the point of loading. By increasing the shaft diameter in (b), the deflection is reduced enough to remove the extra loading on the bearings. In (c) the bearings are shortened in length and their radial clearance is increased to permit unrestricted deflection of the shaft and remove the unnecessary loading. The condition indicated in (a) can develop large friction forces if widely spaced bearings are combined with small shaft clearance and high shaft flexibility.

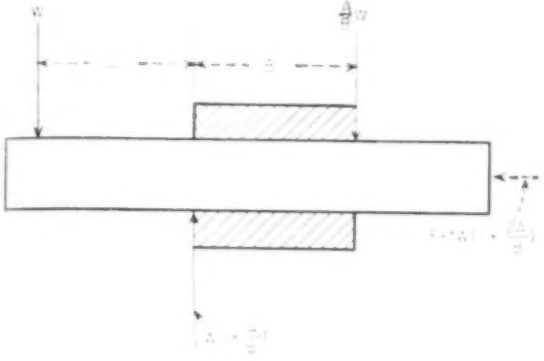

FIG 2

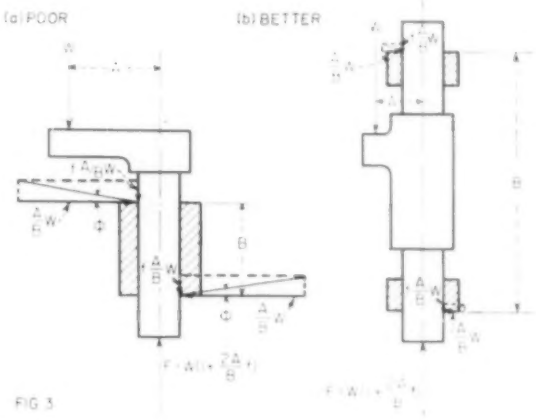


FIG 3

is better illustrated by the weightless block (b) driven by an inclined force $P$. Unless the angle of inclination $\Theta$ is larger than $\phi$, the linkage will jam for any value of the applied force. This jamming tendency often exists in complex mechanisms and is not always so obvious.

OVERHUNG LOAD EFFECT (Fig. 2) The overhung load $W$ sets up balancing bearing forces as shown. Since the friction effect of these forces is additive, the force $F$ that resists linear shaft movement equals $fW(1 + 2A/B)$. For the proportions shown, $A$ equal to $B$, and assuming $f$ equals 0.15, $F$ is $0.45W$. Making $A$ very small relative to $B$, or applying the load between the ends of the bearing surface would effectively divide the above friction force by three.

OFFSET LOADING (Fig. 3) This illustrates the effect of offset loading on a reciprocating shaft and also applies to a rotating shaft. For the proportions shown in (a) and a value of 0.15 for $f$, $F$ equals $1.30W$. The magnitude of $F$ can be reduced to $1.05W$, as shown in (b), by reducing the offset $A$ and increasing $B$.

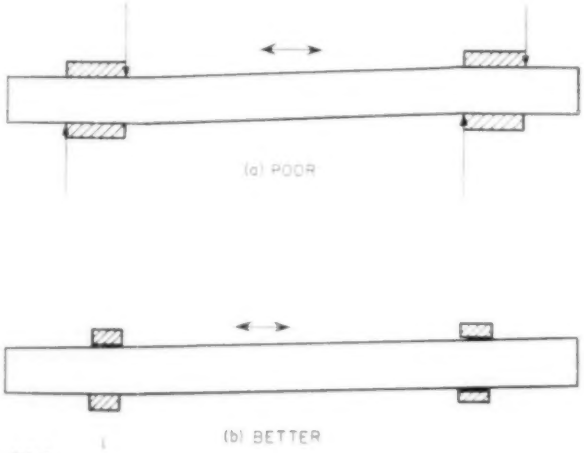


FIG 5

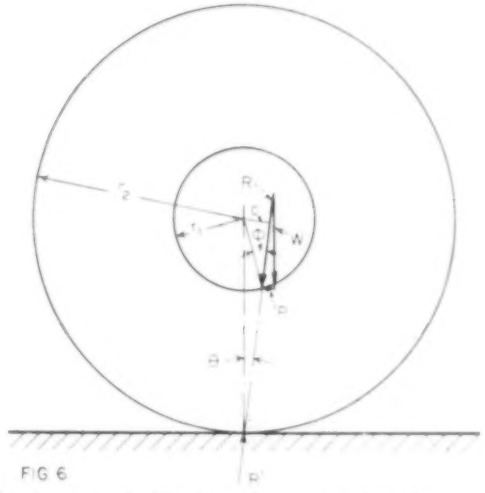

FIG 6

BEARING ECCENTRICITY (Fig. 5) Misalignment of the two bearings in (a) causes shaft deflection with resulting high bearing loads and friction. If the misalignment can not be corrected by line-reaming or closer concentricity tolerances, the bearing loading can be reduced by shortening the bearings and increasing the shaft clearance as in the bottom illustration.

WHEEL (Fig. 6) The wheel shown rotates about a fixed axle and supports a load $W$. The forces on the wheel are the resultant hub force $R$, acting at the angle $\phi$ with the normal to the sliding surface, and the equal and opposite force $R'$ acting through the point of contact with the ground. The line of action of these forces must pass at a distance $c$, equal to $r_1 f$, from the center of the hub. It can be shown that the horizontal driving force $P$ approximately equals $fWr_1/r_2$. Since the effective friction force varies directly with the ratio $r_1/r_2$, reducing this ratio provides the ground more leverage with which to overcome the friction force at the hub, thus reducing the force exerted by the ground to oppose motion of the wheel. This also reduces the driving force required. If $f$ between the wheel and ground is much lower than at the hub, the friction angle at the ground could be less than $\Theta$. Then the wheel would slide instead of turn.

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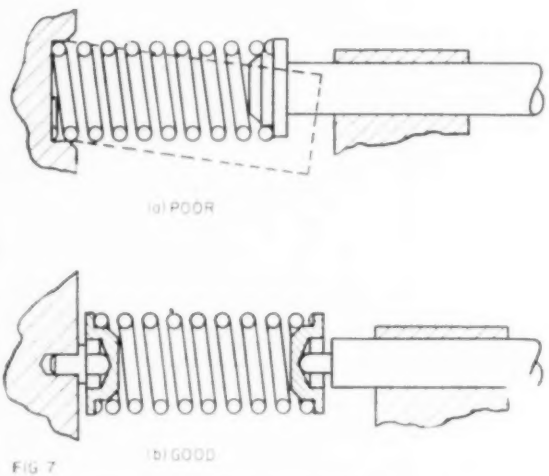


FIG 7

COMPRESSION SPRING MOUNTING (Fig. 7) The spring shown in (a) has its ends forced into concentric and square alignment with the shafts as compared to a free position indicated by the dashed lines. This results in offset and/or angular loading on the shafts and radial loading and friction at the shaft bearings. Allowing the end coils to take their natural position, as in (b) by the use of swivelling retainer cups, the spring force will act along a line of action through the centers of the rounded shaft ends, thus removing the friction effect. This effect is most pronounced when the spring rate is high compared with the applied load.

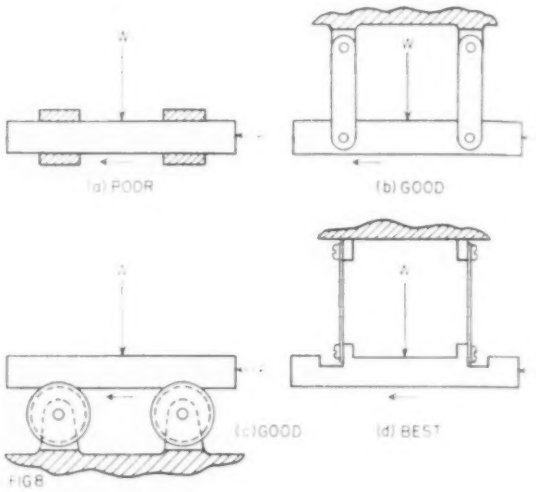


FIG 8

RECIPROCATING MOTION (Fig 8) Frictional forces on a radially loaded reciprocating shaft in plain bearings act against the applied load *P*. These forces can be reduced by pin and link suspension as in (b), or by mounting on rollers as in (c). In (d), friction is eliminated by a suspension on thin leaf springs.

LEVER AND LINKS (Fig. 9) The forces acting on the lever are the link load *W*, the driving force *P*, and the bearing load $(W+P)$. These forces are shown acting tangent to a friction circle whose radius $c$ is

PARALLEL RECIPROCATING MOTION (Fig. 11) It appears that (b) would be better than (a) because for the same stroke there is less lateral rubbing of the lever ends at the travel extremes. And (c) seems better yet because of the reduced radius of the lever ends. Actually, the maximum friction side load effect on the push rods is essentially the same for all three arrangements. Also, the maximum friction torque applied to the lever from its push-rod contacts is essentially proportional to the maximum difference in height of the two rod end surfaces for all three, except that it will be greater for (a) if this difference is less than $2r$. However, (b) and (c), may have advantages with respect to wear or desired motion. In (c) the lever contact moves inward on the rod end surfaces at the travel extremes, thus producing eccentric loading of the push rods and tending to cause friction in the push rod bearings. By lengthening the lever arms slightly, (d), the maximum eccentricity, and thus friction, are reduced. At (e) four thin leaf springs support the lever and replace the pivot.

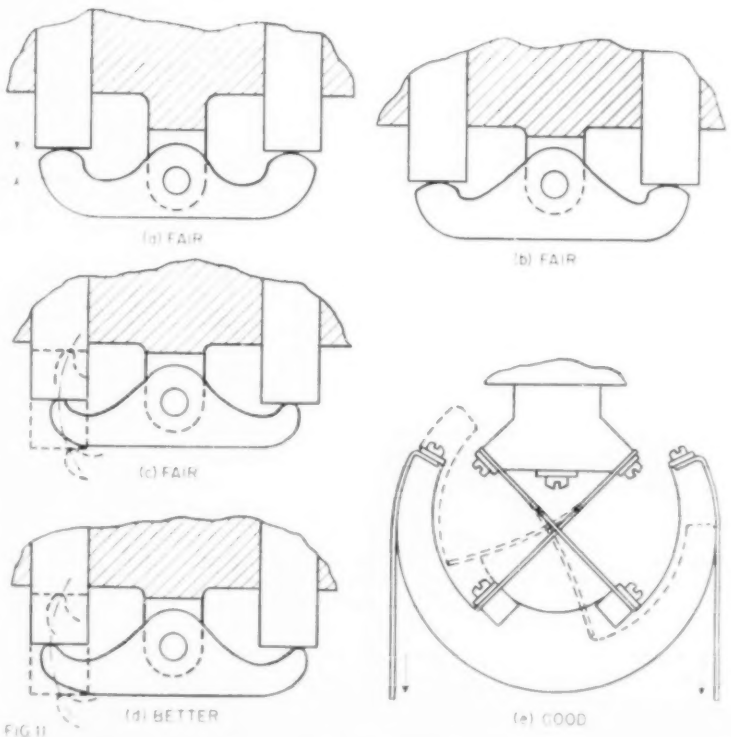


FIG 11

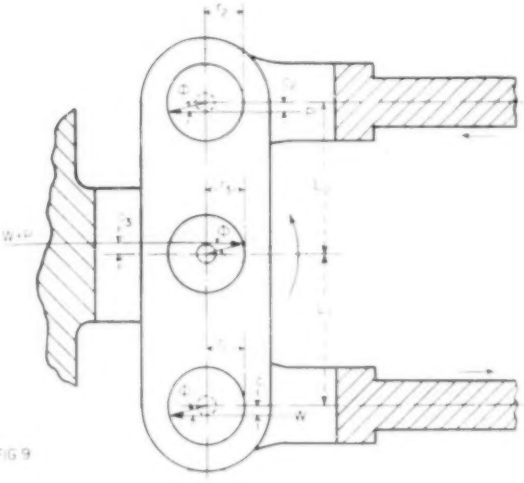

FIG 9

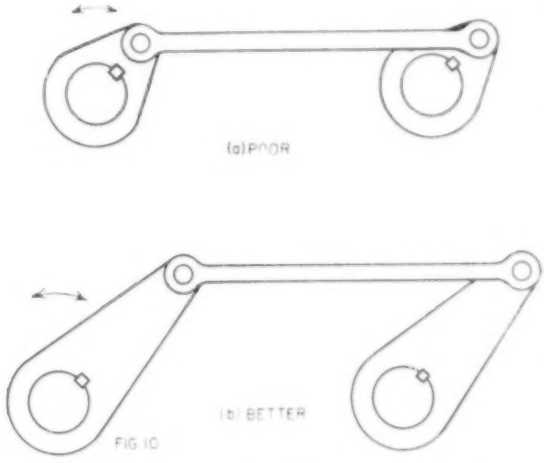


FIG 10

equal to $rf$. By summing the moments about the point of application of the bearing force, the value of $P$ can be found as:

$$P = W\left(\frac{L_1 + f(r_1 + r_3)}{L_2 - f(r_2 + r_3)}\right)$$

To minimize friction, the radii, $r_1$, $r_2$ and $r_3$ should be small compared to $L_1$ and $L_2$. The limiting condition, that of zero friction, is represented by $P = W(L_1/L_2)$. This is approached in practice by the well known balancing scale in which knife edges replace the pin points.

**OSCILLATING SHAFT DRIVE** (Fig. 10) Cranks and a connecting link are often used to transfer oscillating motion from one shaft to another. Assuming that the torque to be transferred is the same for both (a) and (b), the friction effect will be less for (b) because of the lower link load on the connecting pins and the correspondingly lower reaction loads on the shaft bearings. However, this arrangement is only satisfactory for angles of shaft oscillation less than 90 degrees, since the effective lever length as far as bearing loading is concerned is the distance from the link centerline to the line connecting the centers of the shafts.

**CONVERTING OSCILLATING TO RECIPROCATING MOTION** (Fig. 12) Four different means of converting angular motion to linear motion are shown. The amount of normal loading on the reciprocating shaft, represented by the vector $N$, is indicative of the relative friction effect. All means are compared for the same angular stroke, linear stroke, and axial output load at the reciprocating shaft. Except for (b) and (c), the friction load is a maximum at the stroke extremes and increases with the stroke.

In (a) the loading angle $\theta$ is increased by the friction angle $\phi$ to produce a high radial load component. For (b) the gear pressure angle $\theta$ is also increased by $\phi$. If the total angular stroke is less than twice the gear pressure angle, (a) will have less friction than (b). At (c) the angle of loading on the reciprocating shaft is only $\phi$ and the radial load component is less than for (a) or (b). For (d) the maximum angularity of loading is determined by the ratio of the vertical travel component of the lower end to the length of the link, and the normal load component can be small.

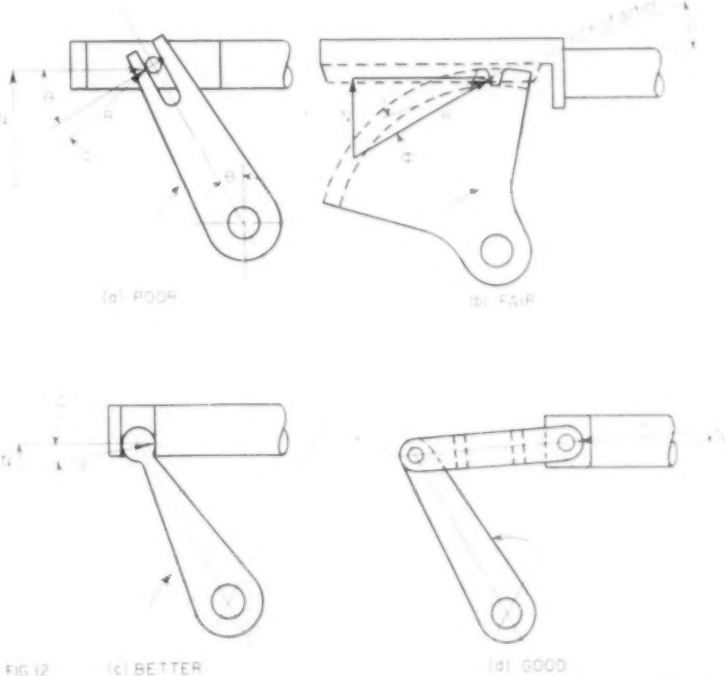


FIG 12

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## Designing for Less Friction (continued)

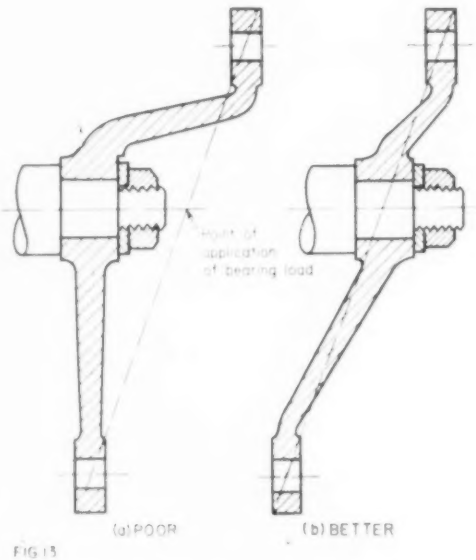



FIG 13

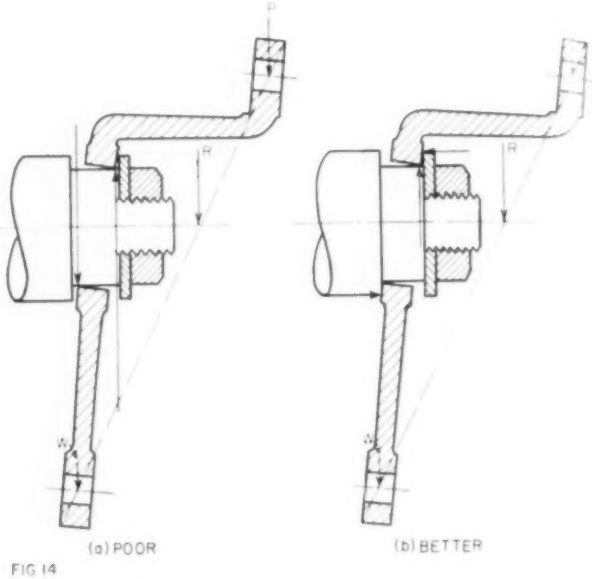



FIG 14

OFFSET LEVERS (Fig. 13) The offset lever in (a) is used for transferring a load between two links. The loads are applied perpendicular to the paper and at the centers of the lever ends. The resultant bearing load falls at a point where the line between these centers crosses the bearing centerline as shown. This produces an overhung load on the bearing with resulting friction increase similar to that considered in Fig. 2. In (b) friction is reduced by eliminating this overhang. Increasing the bearing length would help if the overhang cannot be reduced considerably or avoided. The example in Fig. 14 is an actual case history of a lever of this type.

SPECIAL OFFSET LEVER (Fig. 14) This lever, which was discussed in Fig. 13, has applied force P opposed by a load W. Because there was a large driving force available, the design shown at (a) was accepted in spite of the load offset, large bearing diameter and narrow bearing width. But the lever jammed and was bent out of shape by the driving force. The bearing loading is illustrated as vertical instead of perpendicular to the paper. Space limitations prevented correcting the source of the high friction without redesigning the entire mechanism. However, friction was reduced enough to prevent jamming by allowing the force moment generated by the bearing overhung load to be borne on the

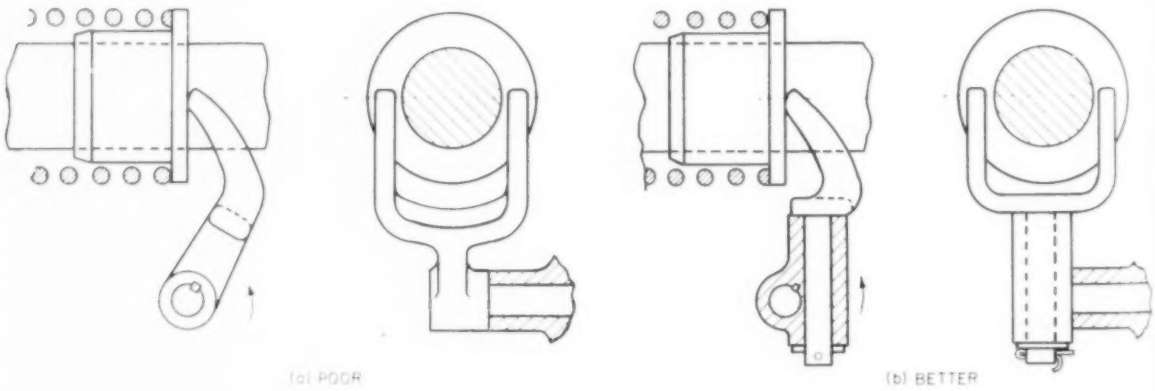



FIG. 17

FORKED LEVERS (Fig. 17) The forked lever shown in (a) drives a loaded sleeve. Unless close machining tolerances are held, this can result in essentially all of the load being carried by one of the two tines. This, of course, causes an offset loading and increased friction forces on the sleeve. By permitting the fork to swivel as in (b), the tine loads are equalized, relieving the offset loading effect and thus reducing the friction.

PRESSURE OPERATED VALVE (Fig. 18) At (a) the valve is positioned by the balancing of the pressure force from the diaphragm against the load of the spring

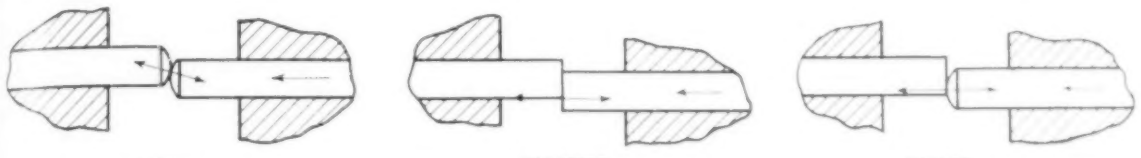



FIG. 15

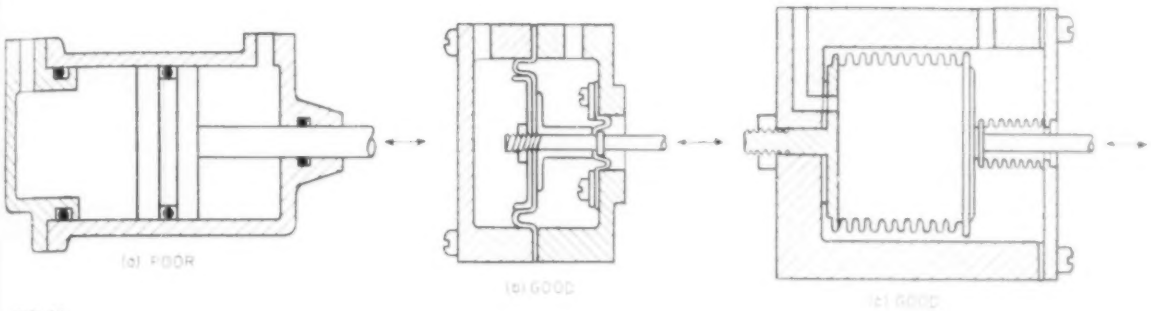



FIG. 16

lever thrust faces. This was done at (b) by adjusting the thrust face clearance relative to the radial bearing clearance so that these faces rather than the bearing carry the major share of the load.

ECCENTRIC PUSH RODS (Fig. 15) Two eccentric shafts are transmitting load in compression only. For (a), rounded ends result in angularity of shaft loading and radial forces on the shaft bearings. In (b), the angularity is removed but all offset loading cannot be eliminated because flat shaft ends cannot be made perfectly parallel. This offset is reduced in (c) thereby minimizing the radial bearing loads and the friction.

PRESSURE OPERATED MECHANISMS (Fig. 16) A simple piston and shaft for a hydraulic cylinder with "O" ring rubber seals are shown in (a). Like any other conventional type seal, these rings cause some friction. In (b) flexible cloth reinforced rubber diaphragms replace the sliding surfaces and eliminate much of the friction and leakage. Metallic bellows are used for the same purpose in (c). These bellows are characterized by a spring rate which must be considered in the design analysis. The diaphragms have little spring effect, but their effective areas tend to vary with movement, causing a reaction during operation that acts similar to a spring effect and thus must often be considered.

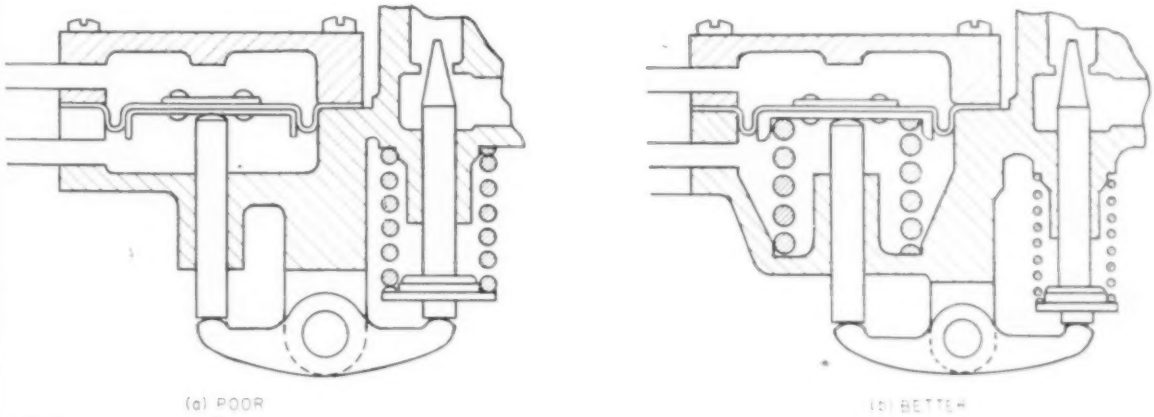
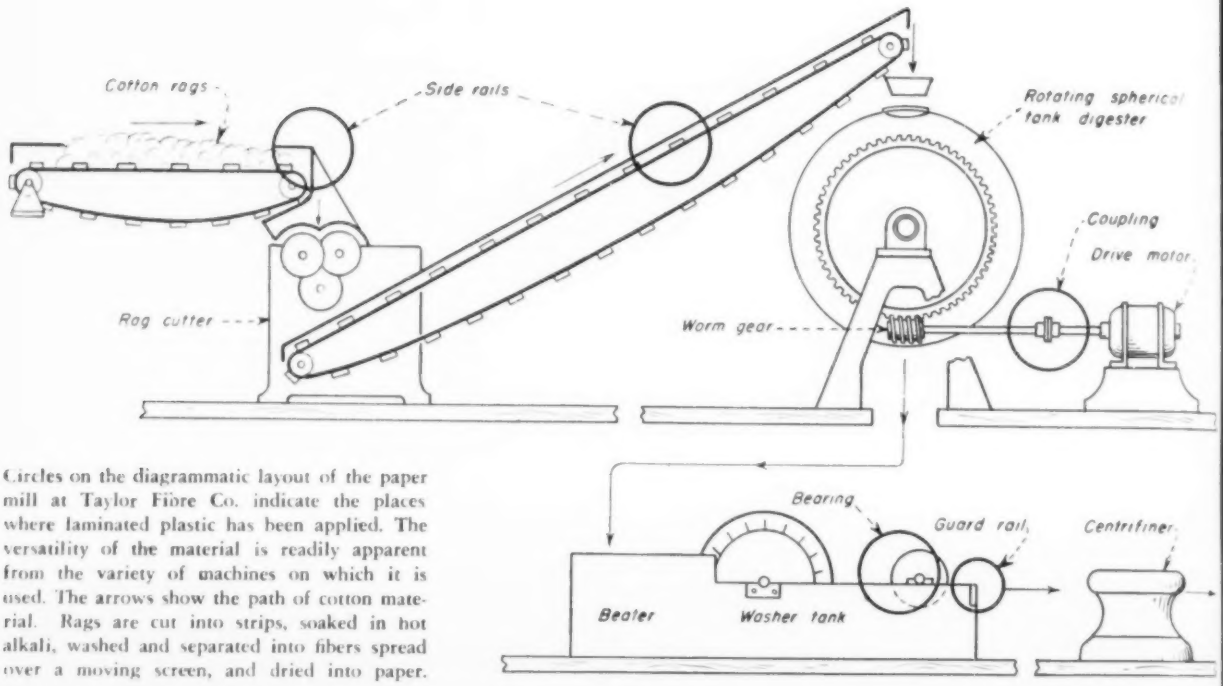



FIG. 18

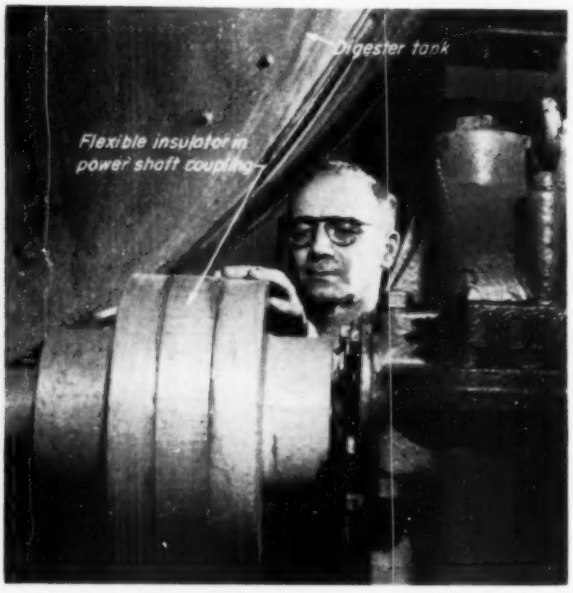
To be sure that a small pressure variation will provide enough force to move the valve, the total diaphragm pressure force must be greater than the valve load. However, friction in the connecting lever or other equivalent connecting mechanism may still cause inaccurate valve positioning. Increasing the pressure force by enlarging the diaphragm and installing a heavier spring will not help, since the increased lever load will cause a proportionate increase in the friction force. By moving the balancing spring as in (b), and adding a light spring to overcome the valve load, the lever forces and friction are reduced and accuracy improved.

# Fabric Base Phenolic Laminate Used




Circles on the diagrammatic layout of the paper mill at Taylor Fibre Co. indicate the places where laminated plastic has been applied. The versatility of the material is readily apparent from the variety of machines on which it is used. The arrows show the path of cotton material. Rags are cut into strips, soaked in hot alkali, washed and separated into fibers spread over a moving screen, and dried into paper.

WEAR QUALITIES of fabric-base phenolic laminate plastic make it a good material for the side rail of the conveyors that transport the abrasive cotton rags.



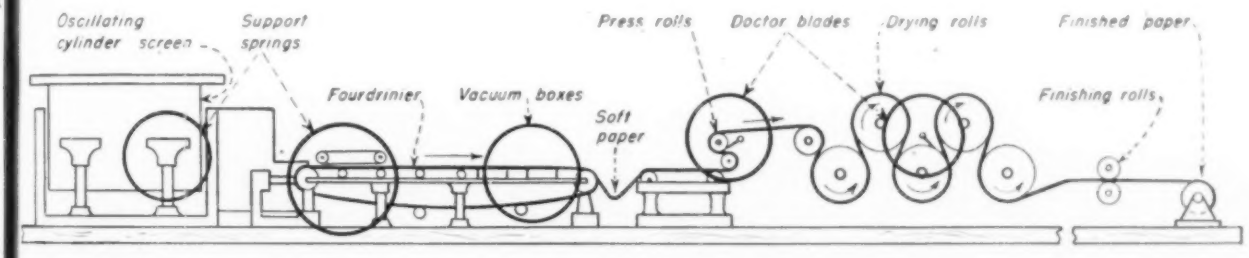

PHENOLIC INSERT in the flexible coupling of the digester power shaft. Wear qualities and compressive strength of material keep bolt holes from enlarging.

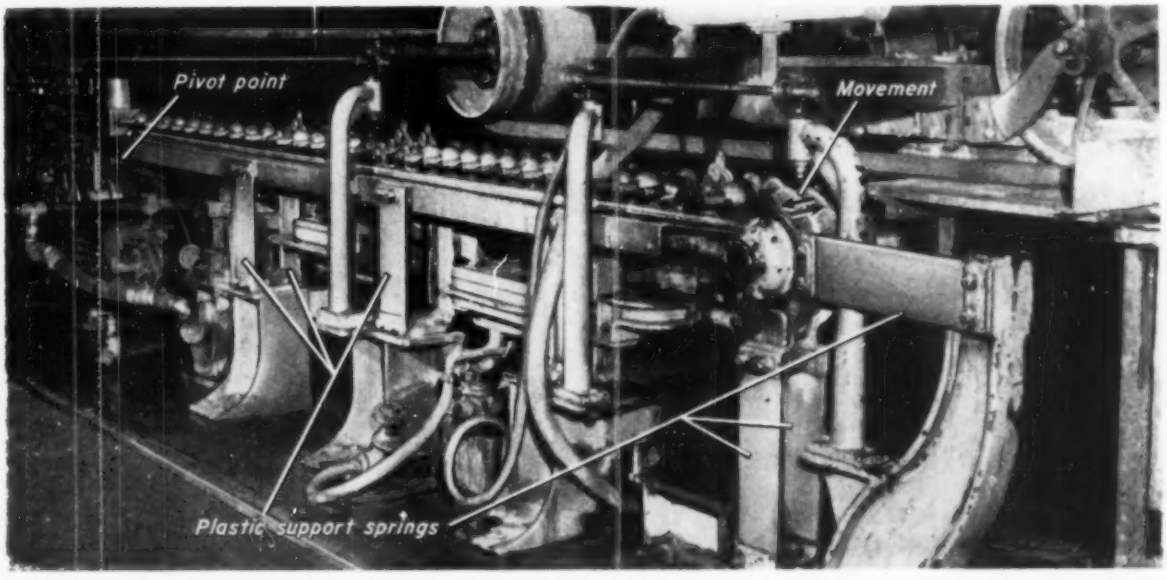
# Many Places in Paper Mill

To take advantage of the moisture and wear resistant qualities of fabric base phenol laminates, the Taylor Fibre Co., Norristown, Pa. has made liberal use of this material for machine components in the paper making section of their plant. Because of the abrasive action of the cotton rags from which the paper is made and the corrosive tendency of the water and chemicals used in the process, the plastic, as a replacement material for metal in several critical parts, has greatly relieved plant maintenance problems.

One of the most unusual applications is found in the Fourdrinier section. Here phenolic springs perform the two-fold action of supporting the roller table and flexing as the table oscillates. Moisture resistant qualities of the laminated plastic is demonstrated where the bronze screen of the Fourdrinier carries the mat of water soaked fibers over perforated covers of the vacuum boxes. Since the white water, drawn from the paper at this point, is reused, any rust particles deposited in the solution endanger the quality of the finished product. Use of phenolic covers eliminates this danger. As doctor blades in the press and drying sections, the relative softness of the phenolic prevents foreign particles from scratching the metal rolls. Taylor grade C was used throughout.

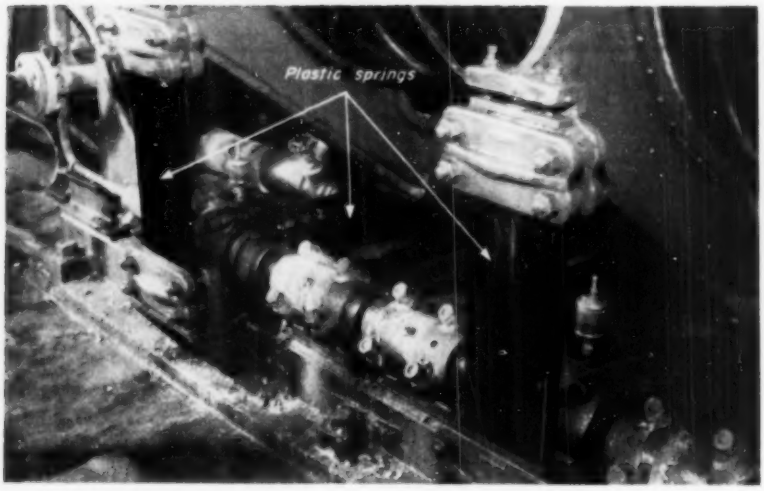
All the phenolic laminate parts have given satisfactory service over an extended period of time.



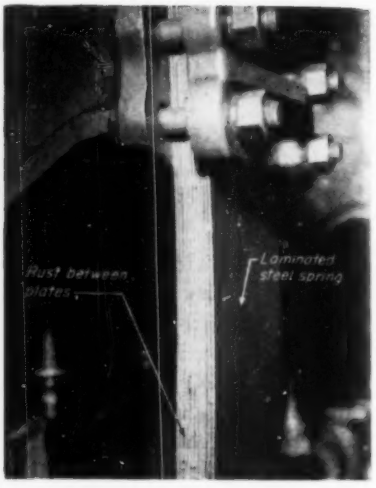




**FABRIC BASED** laminated phenolic plastic springs that support screen table of Fourdrinier section and permit it to oscillate. Maximum movement of the table is about 2 in. and frequency of oscillations is about 100 cps. As the table shakes, a solution of cotton fibers suspended in water is evenly spread over the traveling bronze screen belt.

## Paper Mill (continued)

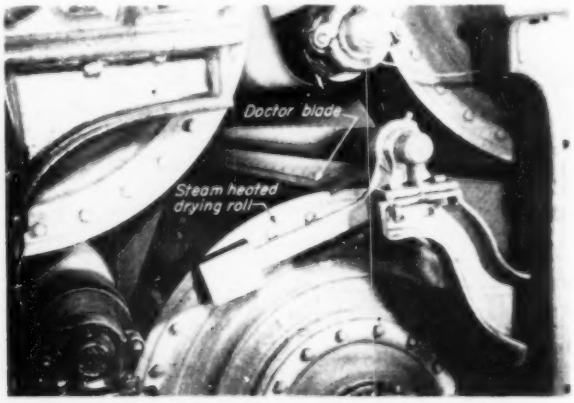



TWO SETS of laminated phenolic springs are used on the oscillating tank of the cylinder screen in which size of the cotton fiber is gaged. One set of springs transmit the oscillating motion to the tank and the second set supports the weight. Movement-characteristics are the same as on the Fourdrinier.

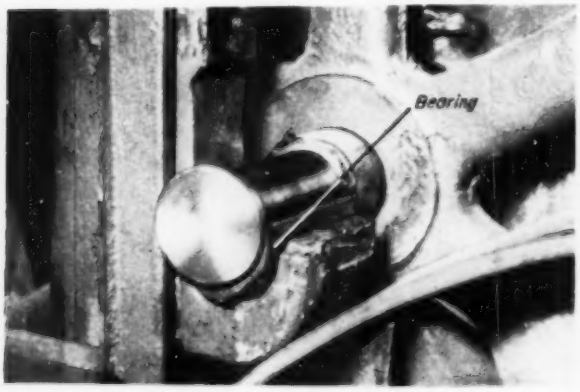



CONDITION of the laminated steel springs previously used on the screen tank. Because of abundance of water, rust forms between the leaves.

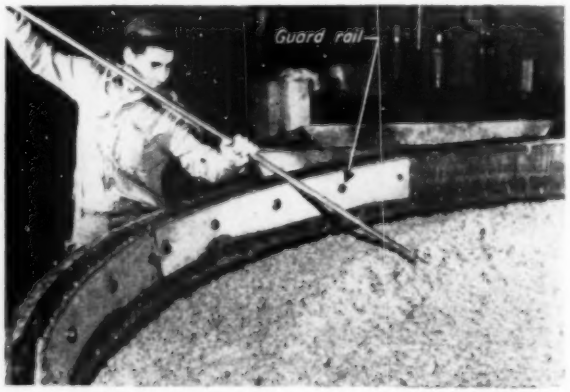
BY REPLACING the steel vacuum box covers with laminated phenolic covers, a severe rust problem was eliminated. Here, vacuum draws water from the wet fiber mat.




DOCTOR BLADES of phenolic laminate are extensively used throughout the mill. Here is shown a blade used to clean one of the heated rolls in the drying section.

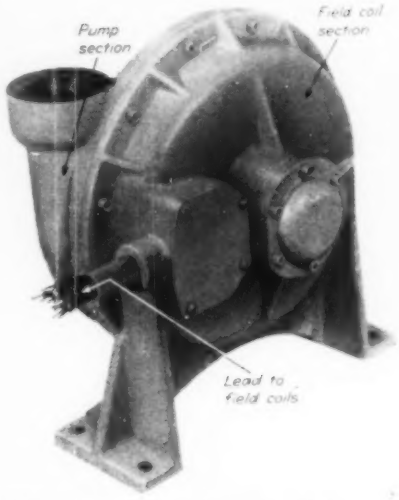



BEARINGS for the hexagon washing drums in the beater vats are laminated phenolic. Water serves as lubricant for plastic but would wash away oil used in other bearings.




COMPRESSIVE STRENGTH and wear qualities of phenolic laminate are used where guard rails of the beater vats support heavy rakes that speed cleaning and refilling.

# Stainless Steel Diaphragm Makes Internal Drive Possible in Pump-Motor Unit

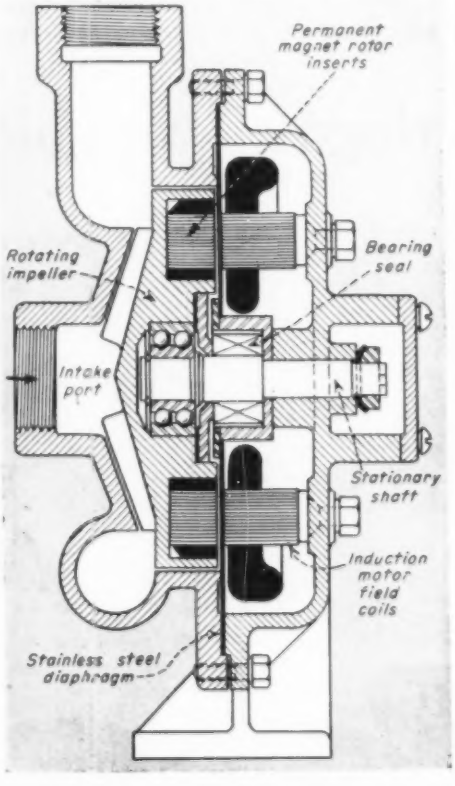


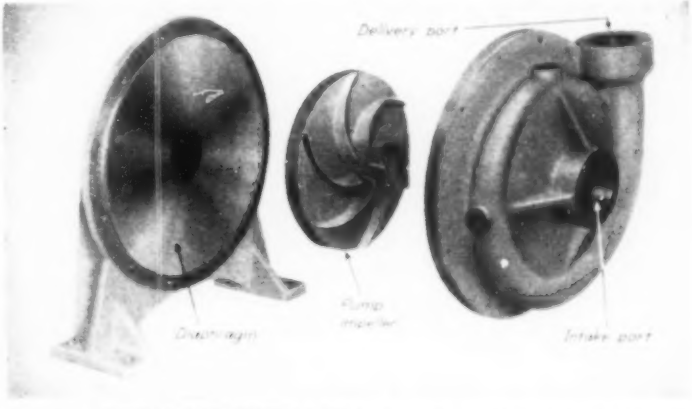

WITH ALL critical components of the combined motor and centrifugal pump inside the single split housing, no protruding power shafts or external seals are required.

By placing a stainless steel diaphragm between the rotor and stator of a radial gap induction motor, a motor-pump unit has been designed that has no external rotating parts and needs no rotating shaft seals. The diaphragm divides the pump into two sections: the pump section with its rotor impeller assembly, and the dry section where the electro-magnetic stator and stationary impeller shaft are mounted. When the two halves of the housing are pulled together by screws, the disk is clamped between them, to hermetically seal each section as an individual compartment.

The rotor of the electric drive and the pump impeller are combined by pressing laminated silicon steel magnets into holes in the back face of the wheel. Directly opposite these magnets on the dry side of the diaphragm are the field coils of the stator.

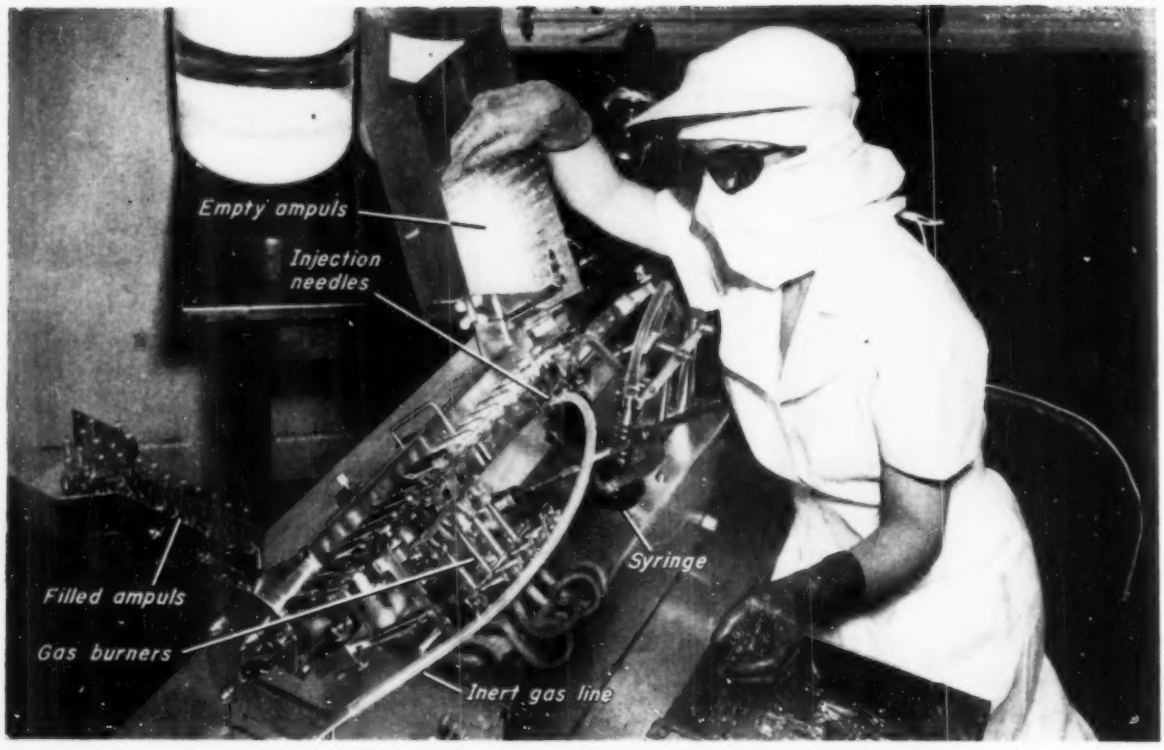
When the field coils of the stator are energized by an a-c current, magnetic lines of force pass through the non-magnetic diaphragm and induce a turning moment in the rotor. Since the power output of this type of motor is proportional to its diameters, there is no mechanical restriction to the capacity of unit that can be made. This pump made by the Atlantic Pump Corporation, Philadelphia, Pa., is presently available in sizes up to 10 horsepower.




ROTATING IMPELLER is the only moving part in the unit. Here is shown the stainless steel partition that separates the fluid and from electro-magnetic field coils of motor drive.

AS SHOWN HERE, spacing and alignment of the impeller is established by factory-sealed bearings of double row angular contact type, held in position by spacers and snap rings. Where conditions permit, nylon, graphite or Teflon bearings can be used to avoid the need for lubrication. The housing can be cast in a variety of materials to meet specific operational needs. Where highly corrosive conditions exist, aluminum, bronze or other rust resistant materials can be used.

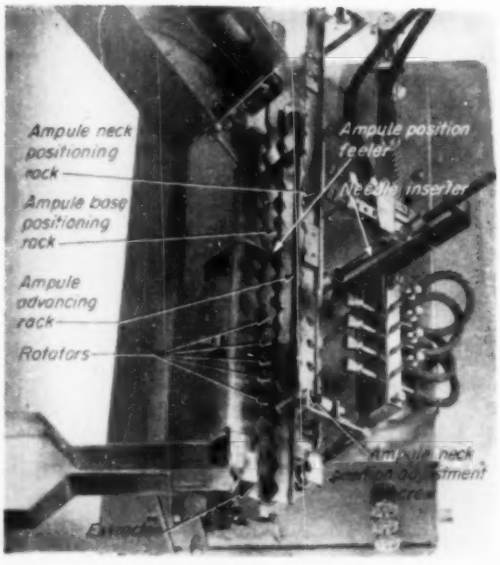


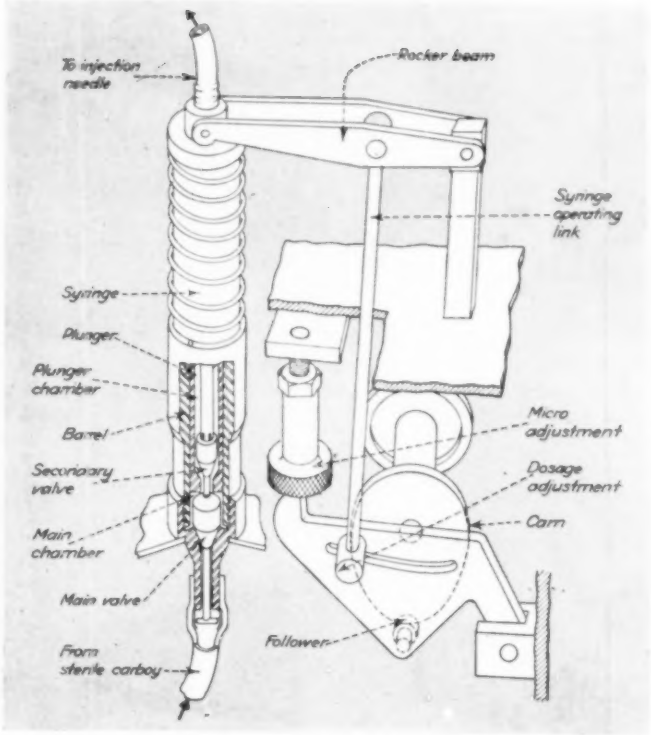

AMPULE FILLING MACHINE in operation requires only manual load and unloading of feed and delivery hoppers. The ampules are indexed past a needle station where they are filled with the pharmaceutical liquid and flushed out with an inert gas; through the flames of four gas burners where they are heat-sealed; and to an extractor that slides them into the delivery hopper. The machine must be thoroughly sterilized and operated in a sterilized room. The operator is usually masked and wears sterilized rubber gloves. The pharmaceutical being processed is passed from the feed container, in the base of the machine, through a sterile carboy in the inlet tube before it reaches the syringe.

# Stainless Steel Syringe of Ampule

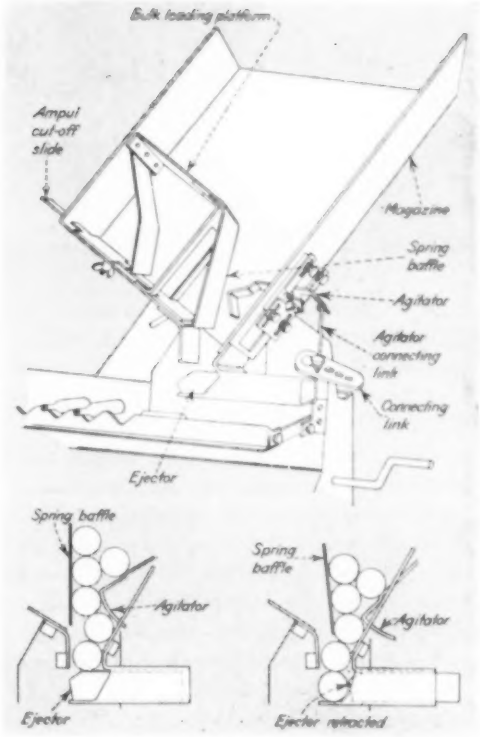
Through the use of a specially designed syringe, a medical ampule filler has been developed by Chase Equipment Corp. of New York in collaboration with Artisan Metal Products Co. of Waltham, Mass., that will fill various size glass ampules, vials or onionskin tubes with exact dosages ranging from 0.1 cc to 33.0 cc. To achieve this degree of accuracy, the barrel, plunger, and valves of the plunger type syringe are honed and machined to tolerances of 0.0002 in. It is made of high nickel stainless steel and since wear resistance is important, all critical parts of the plunger assembly are heat treated. Except for the material being pumped, no lubricant can be used.

Because of the corrosive tendencies of the antibiotics and other pharmaceuticals processed by the machine, extensive use of stainless steel has been made throughout. Lighter metals are used in sections not subjected to corrosion and help keep the overall weight down to 279 lb. All parts are steam proof because the machine must be periodically disassembled and thoroughly steam sterilized. The filler operates automatically and can be adjusted to fill 12 to 46 containers per minute.



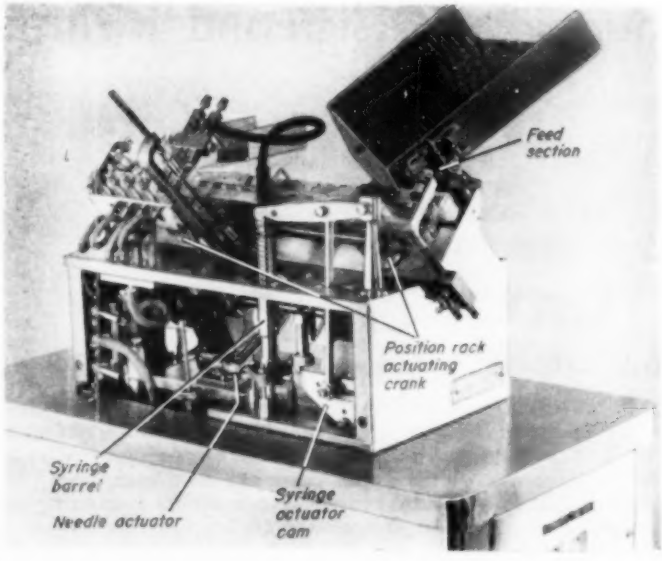



TO DISCHARGE, the cylindrical plunger moves down, the main valve closes, the secondary valve opens. To fill the chamber, the plunger moves upward, the secondary valve closes, the main valve opens. A projection on the secondary valve keeps it open for an instant after the intake stroke begins drawing the drop on the needle back into the line to keep the neck of the ampule dry.




UNUSED AMPULES are fed to the filler from the magazine by an ejector that is synchronized with positioning rack movement. An agitator and spring baffle keep the ampules in position. The connecting link and a drive lug on the underside of the ejector are driven by the main drive shaft.

# Filler Measures Exact Dosages




OVER HEAD view of ampule filler shows crank-operated rack that positions ampules under the filler needles and in front of the gas burners. Rubber-tired rollers rotate the ampules in the gas flame to form an even seal. Pins project from the case to serve as bearings on which the ampules can be easily turned. The position feeler registers the attitude of the ampule and prevents needle from descending if the ampule neck is not aligned.

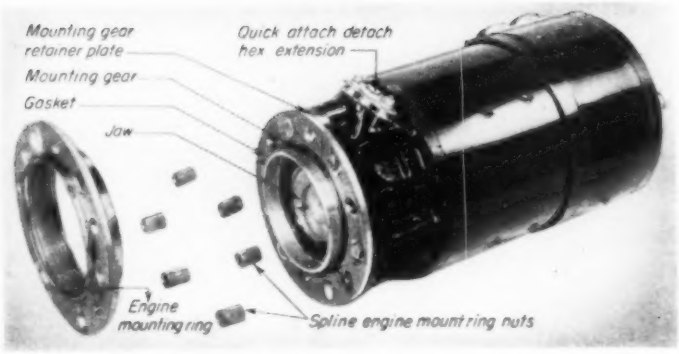
SYRINGE AND NEEDLE actuating mechanism. With the needle rack lowered into position, the cam forces a measured volume of liquid from the syringe barrel through the needle into the ampule. On the return stroke the syringe is filled with a new charge while the needles are retracted and ampules advance one notch. The sequence of operations is regulated through interconnected shafts and power is supplied by a $\frac{1}{6}$ hp motor.

# Jet Starter Has Speed Mounting, Torque Limiter

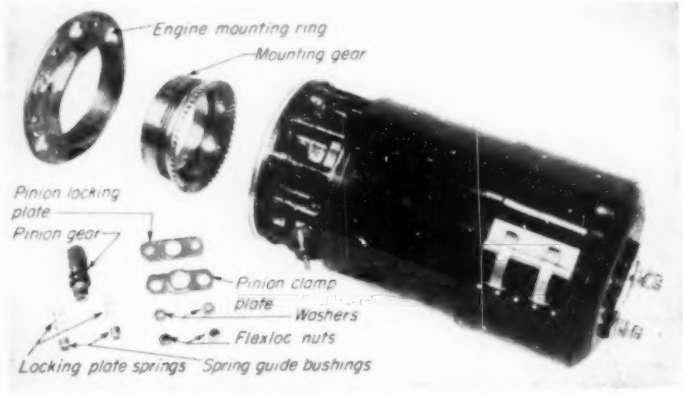
In the process of fulfilling the severe requirements of weight, power, speed and accessibility for jet engine starters, a unit has been developed by Jack and Heintz Inc. of Cleveland, Ohio, that incorporates several unusual features. In previous designs, engagement of the starter jaw, with its counter part in the engine, was accomplished by a d-c electric solenoid that has been a trouble source in starter operation. To eliminate this weakness, the new starter uses a cam actuated jaw with a bronze friction ring retainer that insures positive engagement of the jaws as long as sufficient electrical power is available to rotate the armature.

When service to the unit is necessary, it can be removed from the engine by rotating a single hex knob on the starter gear case. This quick-attach-detach feature facilitates speedy replacement of faulty starters.

To protect the starter from the severe overloads when shaft rotation is restrained, a torque limiter has been included.




JET ENGINE STARTER. Spline headed nuts hold the engine adapter-ing to accessory case and fit into holds of the starter housing to keep the starter from rotating on the engine when the load is applied.



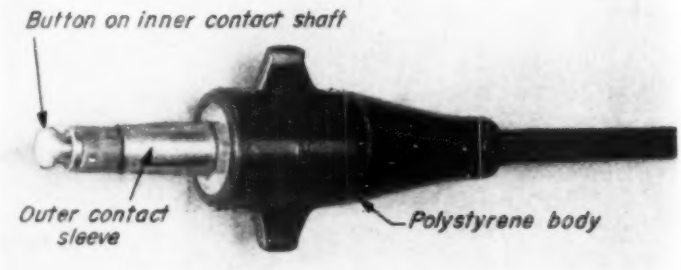

THREADED MOUNTING GEAR is the main element of the quick-attach-detach mechanism in the starter. It is rotated in the housing and screwed into the engine mounting plate by a beveled pinion. The shaft of the pinion extends to the outside of the starter housing.

# Plastic Body Simplifies Design and Reduces

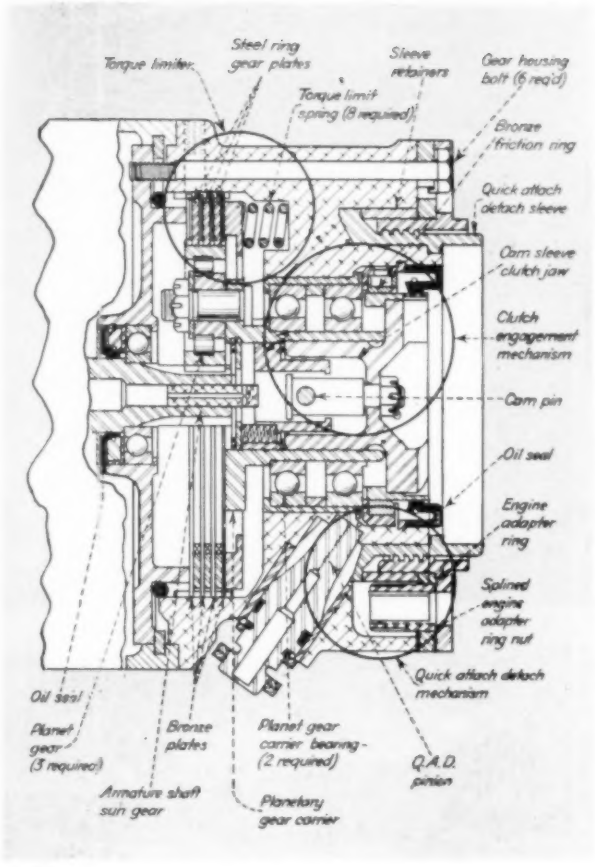
An expendable electric jack plug connector, developed by the Hatfield Wire and Cable Division of the Continental Copper and Steel Industries, Inc., offers another illustration in the design possibilities of plastics.

Used for the end fittings of the ignition leads on air borne rockets, these plastic jack plug connectors offer greater production potential than similar die cast aluminum jacks, have fewer parts, offer more positive electrical connections and use a minimum of critical materials.

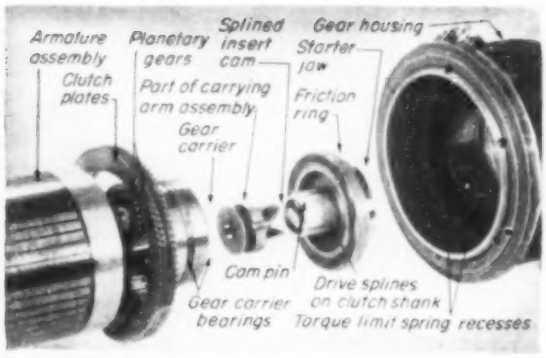
The key to the design lies in the polystyrene body. Here, in one injection nothing, the contract shaft assembly with lead wires is molded and bonded in place.



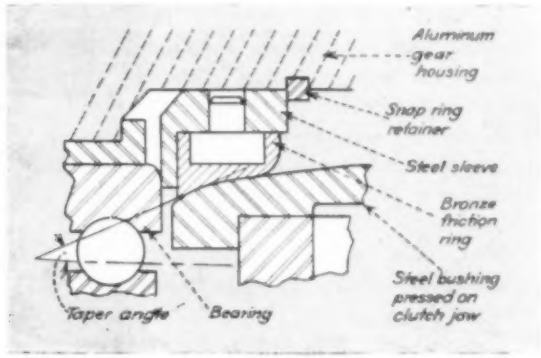

EXPENDABLE JACK PLUG with polystyrene body. This assembly was tested by the Department of the Navy, Bureau of Ordnance, and the Air Corps and has been accepted for use on air-borne rocket igniters. This part goes with the rocket and must be replaced. The polystyrene injection molded housing gives a uniform, moisture-proof, corrosion resistant and tamperproof assembly.




CROSS-SECTIONAL DRAWING shows the arrangement of quick-attach-detach bevel gear drive, laminated ring gear and pressure springs or torque limiter, and friction ring clutch engagement. Circles enclose main elements of features.

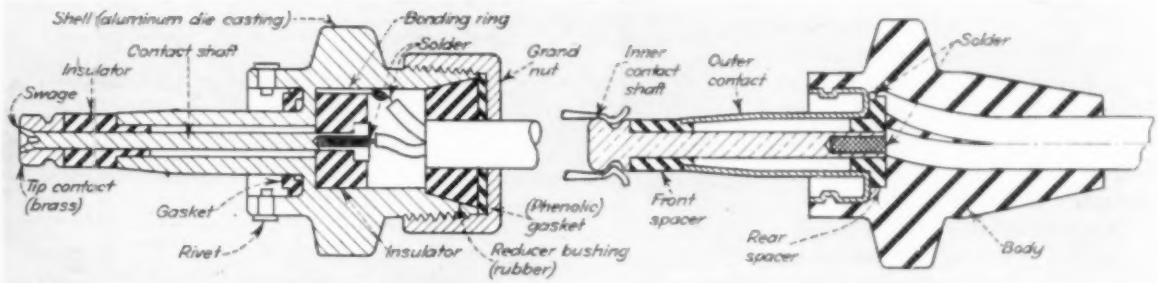



EXPLODED VIEW of the clutch engagement mechanism shows the splined insert cam, and the pin type cam follower that forces the starter jam out of its friction ring and into engagement in the engine. Splines on the clutch shank carry the starting load.




ENGAGEMENT ANGLE on the bronze friction ring insures resistance to clutch rotation until clutch is fully extended. Over riding action drives the jaw back into engagement with friction ring for the next starting cycle.

# Cost of Electrical Jack Plug




COMPARISON of Hatfield jack-plug (left) with a jack of a more conventional die cast aluminum design. In the Hatfield design, the contact assembly is made and lead wires are soldered in place before the polystyrene body is molded on. The bayonet-lock rivets have been replaced by projections in the stamped outer contact shaft and the plastic body removes the need for the rubber seals and gaskets. To prevent the inner contact from pulling out of the body of the new jack, the phenolic rear spacer is bonded to the copper shaft when the two parts are assembled. The molded body offers maximum electrical insulation and forms a built in strain relief for the lead-in wires.

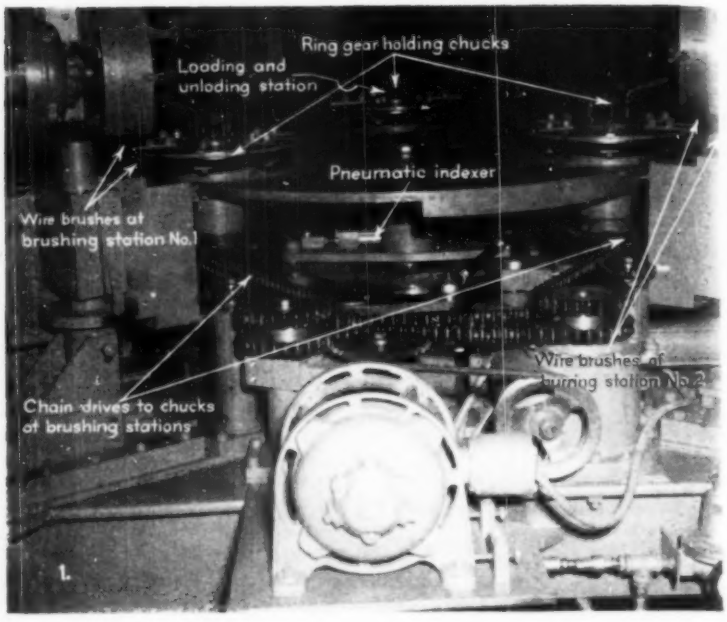
# Continuous Chain Drive Permits Easy Indexing

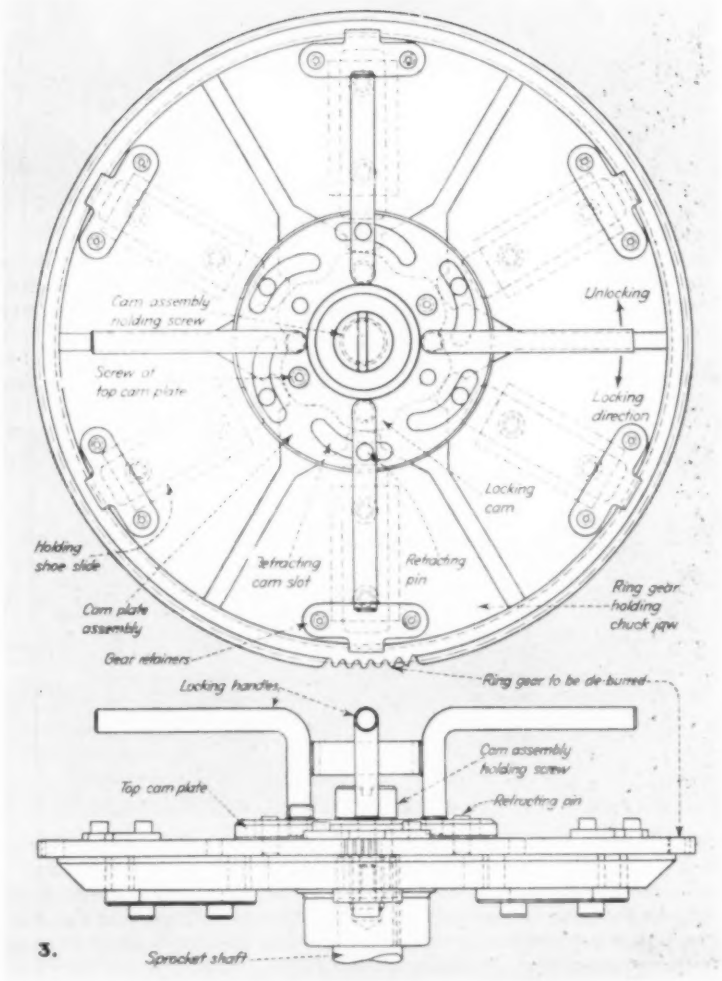
A ring gear deburring ma ine, designed by General Riveters Inc. of Buffalo, N. Y., uses a chain drive that rotates the gear holding chucks at two brushing stations and at the same time permits the indexing rotary table to move the chucks into or out of engagement without necessity of making any preparatory adjustment. Newly machined ring gears are clamped in the chucks at the loading station and are rotated at the brushing station where spinning wire brushes remove burrs and loose chips.

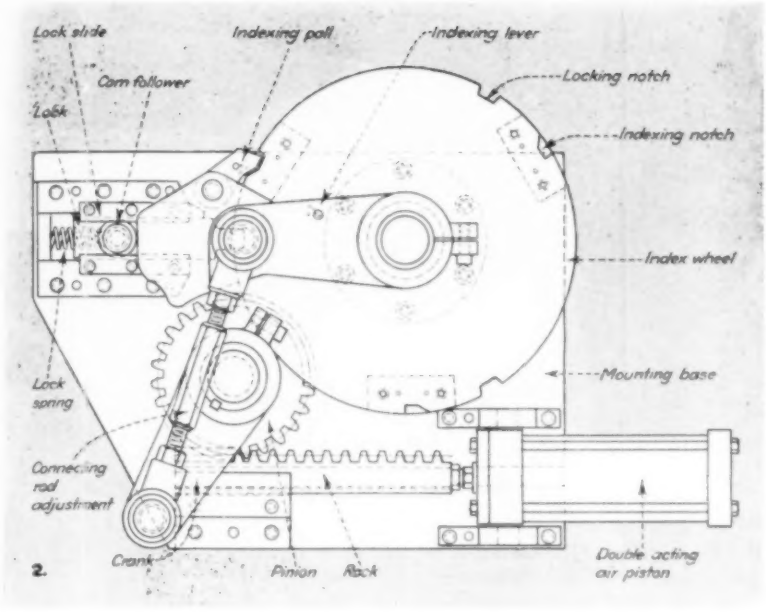
The machine's three ring gear holding chucks are attached to bearing mounted shafts equally spaced around the edge of a rotary table. A pneumatic indexing device periodically rotates the table and locks it in position when each of the three chucks is either at one of the two deburring stations or at the one loading and unloading station. As a chuck moves into a deburring station, the sprocket on its spindle engages the traveling drive chain.

The pneumatic indexing mechanism encorporates a double acting cylinder, with a gear toothed rack extension on its piston rod. This rack, through a mating pinion, actuates an oscillating four bar linkage that engages and turns the rotary work table.

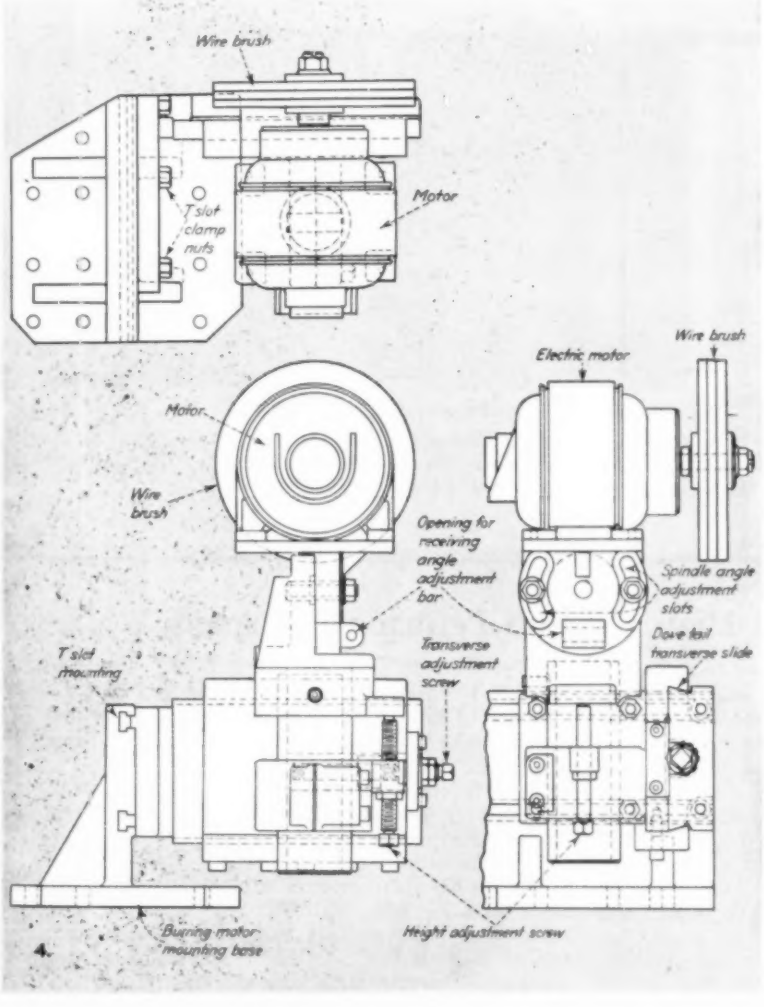
Two wire brushes at each deburring station are individually driven by 3 hp motors at 1,800 rpm. Quick acting chucks permit the operator to load and unload gears at a rate of 6 to 7½ second cycles. The valve on the air supply can be adjusted to change the cycle from 6 seconds to 15 seconds burring time.


Ring gear holding chucks
Loading and unloading station
Pneumatic indexer
Wire brushes at brushing station No.1
Wire brushes at burring station No.2
Chain drives to chucks at brushing stations
1.






**1.** Chains that rotate the chucks at the brushing stations are held at their far ends by idlers and as the table indexes into position, the chains come into engagement and drive the sprockets of the chuck shafts. At the loading and unloading station, the chuck sprocket engages a stationary chain that keeps the chuck still. In the foreground is the main drive motor that delivers power to the rotating chucks. Power is taken from the motor by a V belt to a gear box. The gear box changes the direction of rotation 90 deg and imparts an increased torque into the traveling chain drive. Spring loaded idler sprockets keep the chain drives taut and permit them to give when the burring stations come into position to be rotated.




**2.** Pneumatic cylinder indexes the table through a rack and pinion drive. In the position shown, the indexing operation has just begun. The index wheel lock has been forced out of position by the indexing lever, and the indexing pall is engaged. When lock drops into the next locking notch the air piston will have reached the end of its forward stroke and will slowly return the lever to repeat the cycle. A valve on the air cylinder regulates the speed of the indexing action.

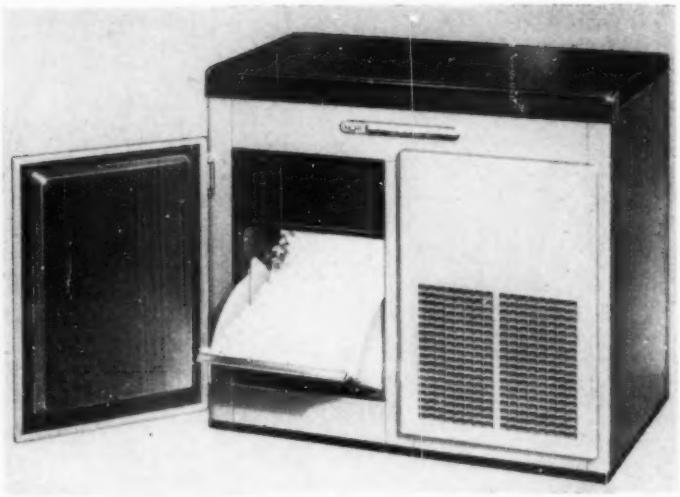
**3.** Cam actuated ring gear holding chuck. To hold ring gear in place, the six chuck jaws are moved outward by a six lobed cam of the cam plate assembly. The chuck jaws are retracted by pins that engage cam slots in the bolted on top member of the cam plate assembly. The clamping handles are welded to the top plate and the unit rotates on a central holding screw as shown on the drawing.

**4.** Tilt of the brushing motor spindles, as well as height and lateral position, can be adjusted to a limited amount. Dovetail slides and square headed jack-screw provide accurate height and transverse adjustment. All four motors have the same adjustment features but modifications were required to permit the inverted position of the bottom brushes.

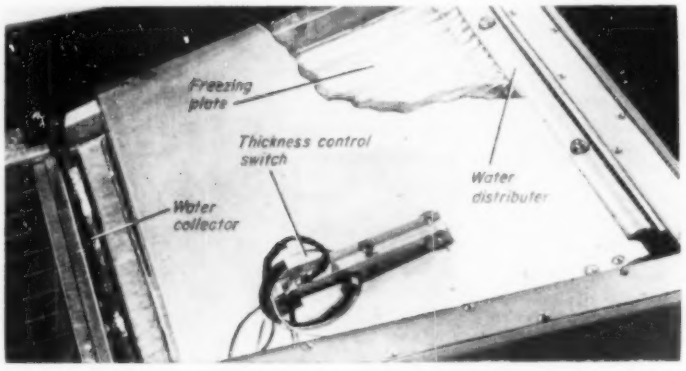
# Ice Cube Maker Works Automatically

**By using a system of mechanical and thermostatic switches to control the refrigerant, feed water and electrical circuits, the cyclic operation of this ice cube maker is automatically maintained. An ice slab is frozen by directing a flow of water over a tilted plate through which a refrigerant is circulated. When the ice slab builds up to a predetermined thickness, a thermostatic switch stops the water pump and opens a solenoid valve that directs hot gas from the receiver to the freezer plate. The ice breaks free from the heated plate and slides onto an assembly of electrically heated cutting grids. The slab of ice melts through the heated grid assembly and into the storage bin as cubes. As it slides into position on the grids it contacts the arm of a heater switch that directs an 11 volt current to a heating element of the thermostat in the ice thickness control. When heated at 46 F it closes the solenoid valve and starts the circulating pump for the next freezing cycle.**

**Made by the Frigidaire Division of General Motors Corp., Dayton, Ohio, the unit is said to have an automatic cube making rate of 5,000 cubes in a 24 hr period.**



CAPACITY of the storage bin in the automatic ice cube maker is 100 lb of ice. The cabinet is 44 1/4 in. long, 31 1/2 in. wide, 38 3/8 in. long, and has a porcelain finish inside and out. When some of the ice cubes in the storage bin have been used, the freezing cycle will start and continue until the used quantity has been replaced.




WHEN THE CIRCULATING PUMP STOPS, all water flows into the reservoir and is automatically syphoned off. The tank immediately refills with fresh water for the next freezing cycle. A float valve in the reservoir maintains the water at proper level.

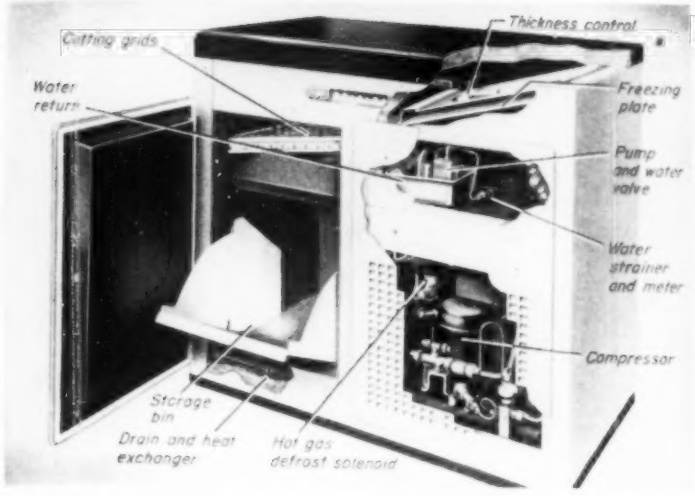
## Applications of High Strength Permanent Magnets

AMONG THE INTERESTING APPLICATIONS found for high strength permanent magnet material is a coupling for the contactor shaft of a stroboscopic lamp made by General Radio Corp. To automatically synchronize the light flash with the turning speed of the machine element under study, the contactor must be directly connected to the rotating part. A permanent magnet on the end of the contactor shaft permits it to be attached to a metal rotating element without use of auxiliary adaptors or couplings. It has enough holding power to drive the contactor shaft and can be simply pulled apart.

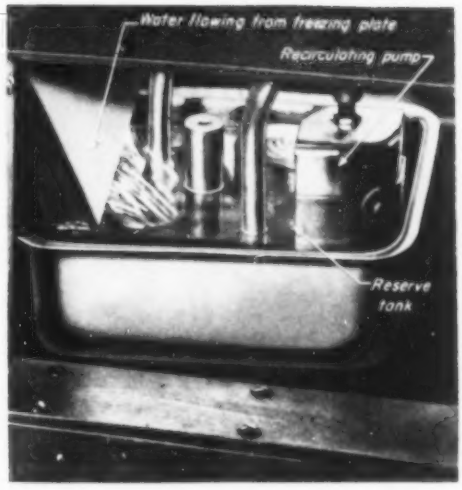
Permanent magnets have been used in several products as door holders. General Electric Company has used it as a door latch on their refrigerator and Saco-Lowell Company of Boston, Mass. has applied it to the door on the gear cabinet of their new textile spinning frame.

Magnetic tension, produced by the attraction of a magnetic field for other magnetic materials, has been used to actuate snap switches, thermostats, and pressure controls. Permanent magnets have replaced springs for many applications of this nature.

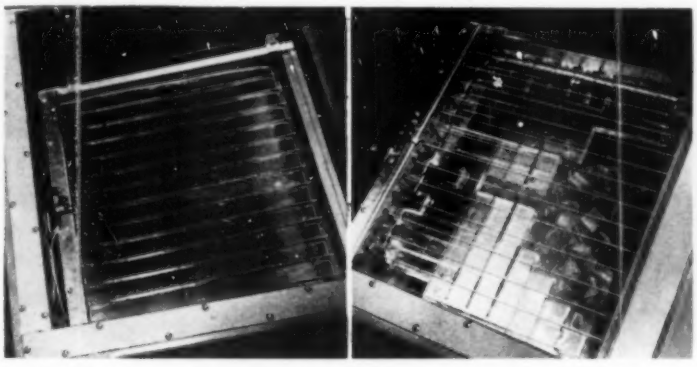
Magnets have been used for some time to separate tramp metal particles from hydraulic and pneumatic circuits. Now, with high intensity magnetic material available, smaller magnets can be made to fit the more delicate systems of laboratory test stands, and flow meters.



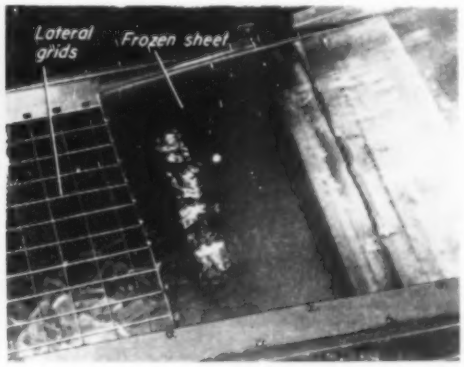

CUTAWAY VIEW of ice cube maker shows arrangement of component parts. A standard ½ h.p. Frigidaire compressor unit pumps refrigerant through system. Heat exchanger coils which precool incoming water are under the ice cube bin. A strainer and water flow metering assembly delivers clean water at 20 gallons per hour.




A CENTRIFUGAL PUMP circulates the water to the freezer plate. When the ice slab reaches the desired thickness, the thermostat stops the circulating pump and causes the solenoid valve to pass hot gas to the freezing plate.



THE ICE SLAB IS CUT into cubes by two sets of wires at right angles to each other warmed by an 11-volt current supplied from a step-down transformer located in the machine compartment. After the cubes are completely cut they fall into the storage bin below.




Hot gas warms the freezer plate and permits the slab of ice to break free. When the ice slab is completely onto the cutting grid, it closes a heater switch on the left side of the grid.

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A sheet steel separator is being manufactured by Carboloy, Department of G. E., Detroit, Michigan, that uses a high strength magnet mounted in a non-metallic housing. When the unit is held against the edge of a stack of sheet steel, the sheets separate and adhere individually to the stainless steel face of the separator. The non-magnetic face plate is used to furnish an air gap between the magnet and work.

Typical of the material used in high strength magnets is Hyflex Alnico V made by the Indiana Steel Products Company, Valparaiso, Indiana. Owing to its hardness this material cannot be readily machined. Consequently, the magnets must be cast in shape, and finished surfaces are obtained by grinding. Inserts of mild steel can be introduced at the time of casting and must be designed to take into account the shrinkage factor of the magnetic material.

| CAST ALNICO | |
|---|---|
| Dimensions | Tolerances |
| From 0 to 2 in. | ±0.015 |
| 2 to 4 in. | ±0.032 |
| 4 to 6 in. | ±0.045 |

| SINTERED ALNICO | |
|---|---|
| From 0 to 0.125 in. | ±0.005 in. |
| 0.126 to 0.625 in. | ±0.010 in. |
| 0.626 to 1.250 in. | ±0.015 in. |
| 1.251 to 3.000 in. | ±0.031 in. |

The table above, taken from Carboloy Bulletin PM100, shows the normal lineal tolerances that can be expected in two commercial types of high strength permanent magnet material.

# How to Specify Precision Knurls

GEORGE BARROW
Westinghouse Electric Corp.

**It takes more than a single adjective or short note on a drawing to specify a straight knurl on which tolerances are critical. An accurate method of designation such as the dimensioning system proposed by the author herein is required.**

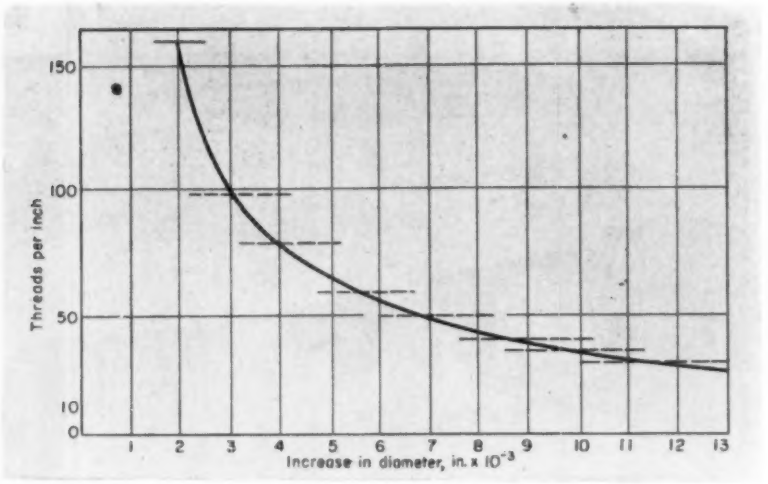



Fig. 2—Data for steel, brass and aluminum for selecting a tool pitch to give the desired increase in outside diameter or buildup.

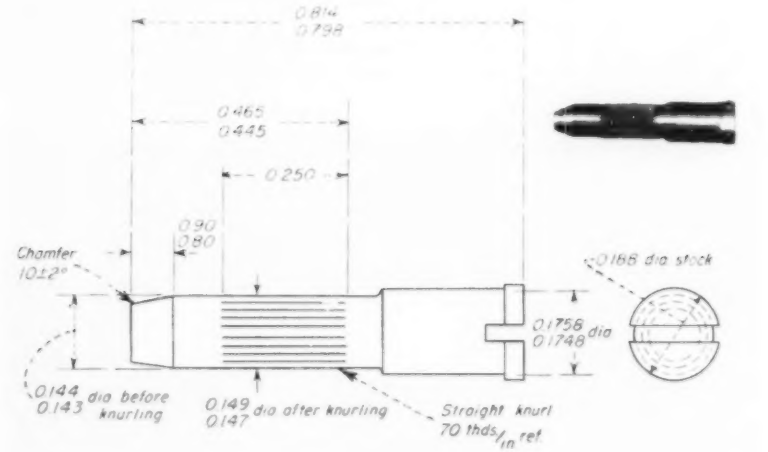



Fig. 3—Actual detail drawing for this precision parts used the designation "Medium Straight Knurl." Preferred system of specifying the information is shown.

FREQUENTLY, knurls are specified on drawings by the general classifications of fine, medium or coarse. Since knurled parts are seldom trade items and there is no standardization as such, this system of designation tends to put the responsibility for the end-product on the machine operator rather than on the designer. Furthermore, what is considered a medium knurl by one operator can be a fine, or even a coarse one, to an operator in a different shop or another machine operator in the same shop. This leads to non-uniformity of products, and does not provide control over critical dimensions.

Of course, precision is not always required. Some types of knurls, such as diagonal tooth or diamond shaped, are widely used to hold studs or inserts in die castings and molded plastic products. Close tolerances are unnecessary in these cases since the material will always mate intimately with the surface. The same condition exists if the serrations are used for decorative or grip purposes.

But some products, particularly small machine elements that employ straight knurling to obtain a press fit assembly, require a rigid system of designation. The degree of this minimal fit must be sufficient to meet performance requirements and forms the basis for the maximum press fit that occurs with the maximum diameter of the shaft and the minimum diameter of the hole in the hub or bushing. The following specification procedure was developed primarily for applications of this type.

## Specification Procedure

Establishing a designation system that is both accurate and practical from a production standpoint involves two factors. One is the relation between the diameter of stock and pitch of the teeth to prevent double knurling or splitting of serrations on repeated revolutions of the work against the tool. This requires an approximately even division of the circumference of the stock by the tooth pitch. Except in special cases where conditions warrant tool development it is unnecessary to compute the exact pitch size and supply a special tool for each diameter of stock encountered. A more practical solution is for the designer to concentrate on the necessary buildup, or increase in diameter, and allow the shop freedom in select-

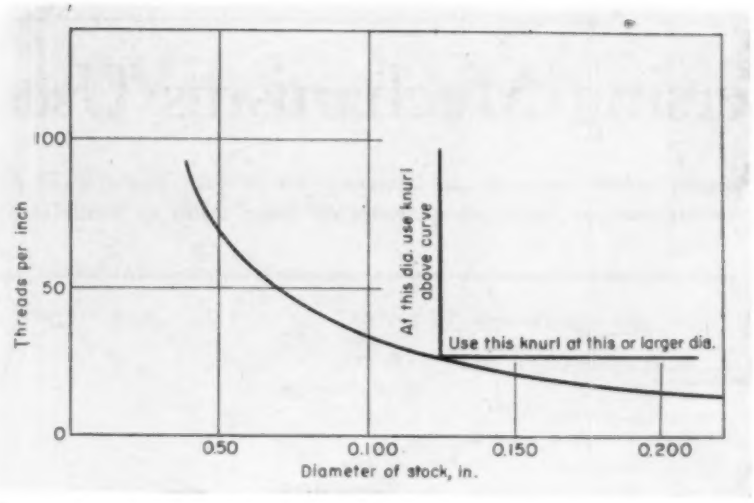



Fig. 2—Approximate range of tool pitches that can be used with given stock diameters. Combinations that fall beneath the curve are to be avoided.

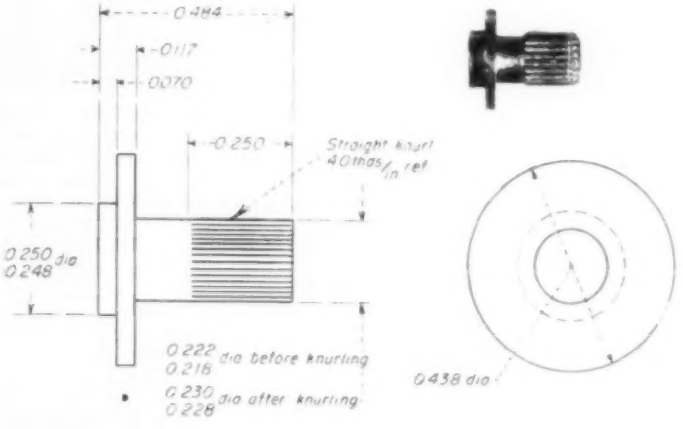



Fig. 4—This knurl was originally specified as "Standard Fine." Following the authors suggestions, the part is detailed above to eliminate such arbitrary classifications.

ing the final pitch. An approximate pitch can be suggested if modifications are allowed to prevent double-knurling. Thus, a change from 40 to 41 or from 47 to 50 threads per inch, as determined by the setup man, is usually better assurance of satisfactory results than the use of an untried calculated pitch for a given diameter.

The other factor, which was referred to previously, is the final diameter of the knurled area. For this, the classifications fine, medium and coarse, are entirely inadequate. From a practical basis, twelve is the minimum number of serrations that can be made on a given diameter of stock and yet retain good workmanship. This gives the maximum increase in diameter and can be designated the coarsest knurl. Reducing the pitch reduces the buildup and increases the number of serrations for a given diameter stock until at some point the result can be termed medium or fine. However, the buildup in diameter over the final surface is the important factor and the resulting number of serrations is secondary.

Data on the buildup of steel, brass and aluminum stock is given in Fig 1 to guide in the selection of a knurl tool. For a given pitch, the buildup increases slightly with increase in diameter of stock. The range is indicated by the short lines through the curve and parallel to the abscissa. The left end of the line represents the minimum of twelve serrations and indicates the buildup on a diameter of stock derived by dividing a constant 3.82 by the threads per inch. The other end of the line indicates the maximum buildup for the same knurl on a diameter of stock approximately 6.4 divided by threads per inch. Further increases in the diameter of the stock will not affect the amount of buildup.

Knowing the diameter of stock to be worked and the buildup required, in thousandths, an approximate tool pitch can be determined from the curve. The derivation of the constant 3.82 is as follows: *

$$\frac{C}{N} = p$$

$$P = \frac{1}{p} = \frac{N}{C} = \frac{N}{\pi D}$$

When $N = 12$

$PD = 3.82$

$N$ = number of serrations
$D$ = diameter of stock before knurling
$C$ = circumference of stock before knurling
$P = 1/p$, threads per inch
$p$ = pitch

The use of constant 3.82 permits further enlargement of data as demonstrated by Fig. 2. This curve shows the approximate minimum limit for a given diameter of stock or a given pitch of tool to produce the twelve-serration type of area. For example, with a tool having 30 threads per inch the minimum diameter of stock on which it can be used is 0.127 in., but it can be used on any larger diameter stock, in which case it will make more than twelve serrations. Likewise it is seen that, at 0.127-in. diameter, 30 is the largest pitch that can be used, but tools with a smaller pitch can be used and if they are, more than twelve serrations will be made. Therefore, the area under the curve represents combinations of threads per inch and stock diameter that should be avoided.

A suggested designation for specifying this information on engineering drawings is shown in Figs. 3 and 4. The nominal increases in the diameters of the knurled areas for these two precision parts are 0.0045 and 0.009 in., respectively. From Fig. 1, the suggested pitches are 70 and 40 threads per inch, respectively. These sizes are shown on the drawing for reference only. Alternatively, these values could have been specified by the designer with an appropriate tolerance. The diameter of the knurled area, which in the final analysis is the important detail, is specified definitely in both the before and after conditions. Sufficient information and latitude are given to permit manufacture and inspection of the critical areas without further questions or possibility of misinterpreting the designer's needs and specifications.

# Traversing Mechanisms Used

**The seven mechanisms shown below are used on different types of yarn and coil winding machines. Their fundamentals, however, may be applicable to other machines which require**

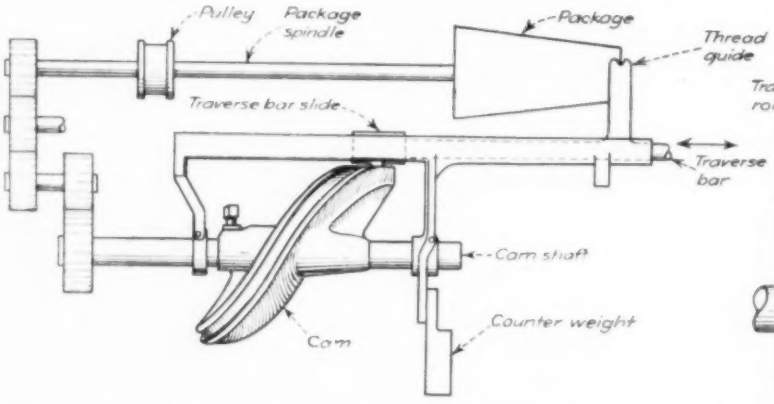



FIG. 1. Package is mounted on belt driven shaft on this precision type winding mechanism. Cam shaft imparts reciprocating motion to traverse bar by means of cam roll that runs in cam groove. Gears determine speed ratio between cam and package. Thread guide is attached to traverse bar. Counterweight keeps thread guide against package.

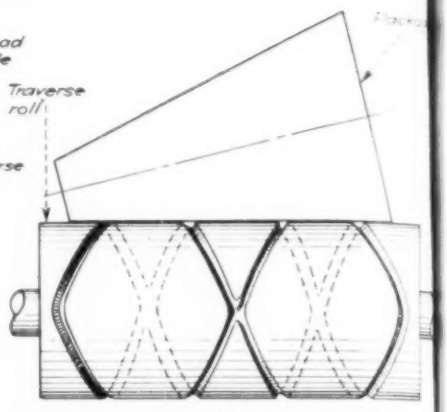



FIG. 2. Package is friction-driven from traverse roll. Yarn is drawn from the supply source by traverse roll and is transferred to package from the continuous groove in the roll. Different winds are obtained by varying the grooved path.

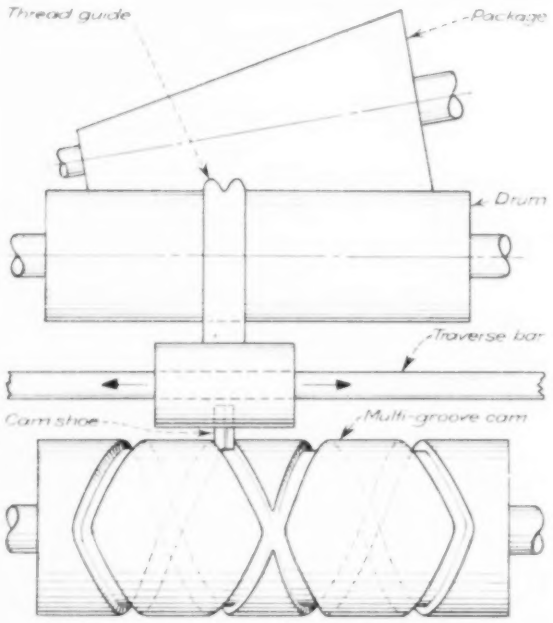



FIG. 4. Drum drives package by friction. Pointed cam shoe which pivots in the bottom side of the thread guide assembly rides in cam grooves and produces reciprocating motion of the thread guide assembly on the traverse bar. Plastic cams have proved quite satisfactory even with fast traverse speeds. Interchangeable cams permit a wide variety of winds.

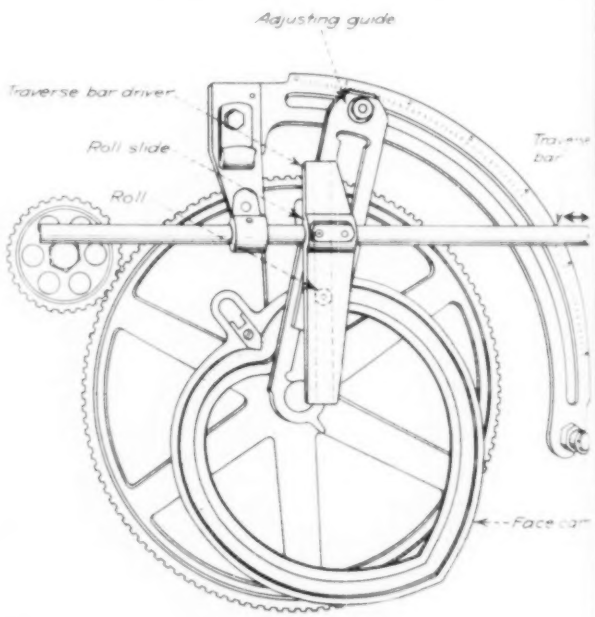



FIG. 5. Roll that rides in heart-shaped cam groove engages slot in traverse bar driver which is attached to the traverse bar. Maximum traverse is obtained when adjusting guide is perpendicular to the driver. As angle between guide and driver is decreased, traverse decreases proportionately. Inertia effects limit this type mechanism to slow speeds.

# on Winding Machines

E. R. SWANSON
Universal Winding Company

similar changes of motion. Except for the lead screw as used, for example on lathes, these seven represent the operating principles of all well-known, mechanical types of traversing devices.

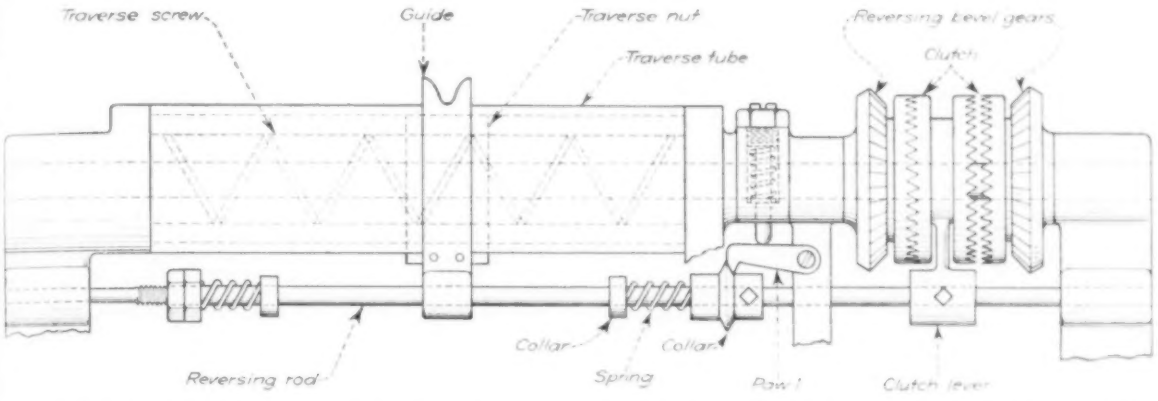



FIG. 5. Reversing bevel gears which are driven by a common bevel gear, drive the shaft carrying the traverse screw. Traverse nut mates with this screw and is connected to the yarn guide. Guide slides along the reversing rod. When nut reaches end of its travel, the thread guide compresses the spring that actuates the pawl and the reversing lever. This engages the clutch that rotates the traverse screw in the opposite direction. As indicated by the large pitch on the screw, this mechanism is limited to low speeds, but permits longer lengths of traverse than most of the others shown.

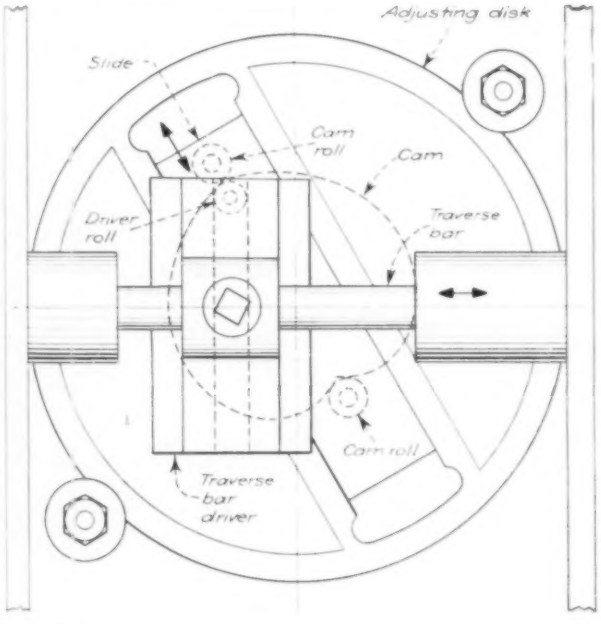



FIG. 6. Two cam rolls that engage heart shaped cam are attached to the slide. Slide has a driver roll that engages a slot in the traverse bar driver. Maximum traverse (to capacity of cam) occurs when adjusting disk is set so slide is parallel to traverse bar. As angle between traverse bar and slide increases, traverse decreases. At 90 deg traverse is zero.

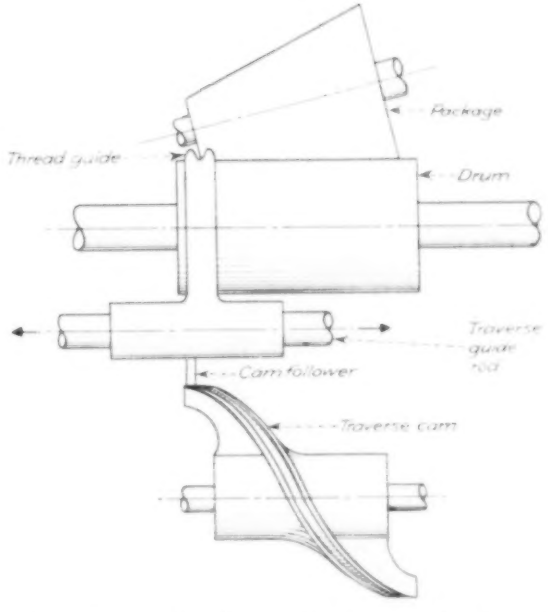



FIG. 7. Traverse cam imparts reciprocating motion to cam follower which drives thread guides on traverse guide rods. Package is friction driven from drum. Yarn is drawn from the supply source through thread guide and transferred to the drum-driven package. Speed of this type of mechanism is determined by the weight of the reciprocating parts.

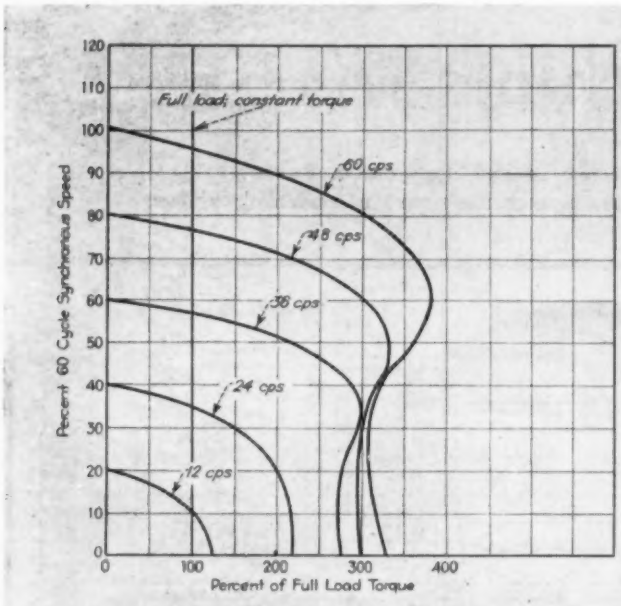



**Fig. 1 — Speed-torque curves for a three phase squirrel cage motor. Drooping characteristic is an advantage since motors tend to divide load equally without adjustment.**

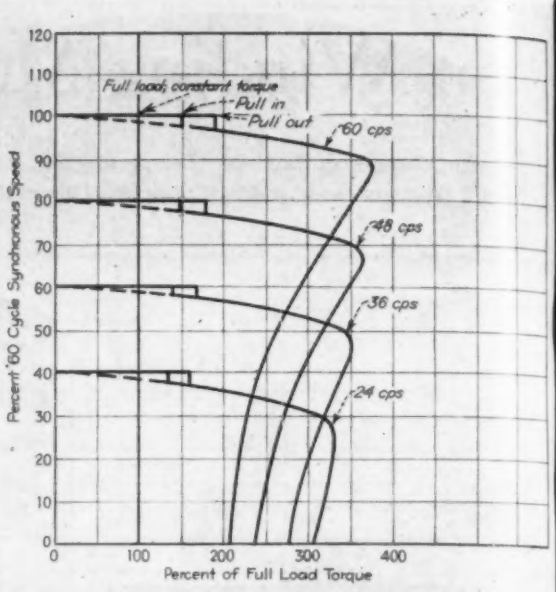



**Fig. 2 — Speed-torque relationships for 6-pole synchronous motor with squirrel cage starting. These motors operate at substantially constant speed with varying loads.**

# Adjustable Frequency Multi-

**Adjusting the speed of a machine that is driven by several motors is a special problem in control. The adjustable frequency technique is a successful solution, offering the benefits of good regulation, economy and wide speed ranges.**

H. L. McCLEERY*

As PRODUCTION MACHINES become larger or operate at higher speeds, it is increasingly desirable to resort to individual electric motor drives for the various sections. The design complications, initial cost and maintenance of line shaft drives are greatly responsible for the swing to multi-motor drives. However, the use of several motors in a machine drive complicates the problem of speed control.

The well known Ward Leonard control system consist of an a-c to d-c motor generator set, which furnishes adjustable armature voltage to the various individual motors. This system is successful on machines requiring a wide range of overall speed adjustment, as well as individual unit speed changes where close speed regulation with load, temperature and voltage changes are not too important. In many cases, poor regulation is a contributing factor to the success of the drive, particularly where some tension is required in the product between sections. If the speed regulation is important, then the load and temperature changes may require that the motor operator readjust the vernier field resistance to keep the loads or speeds equalized. A great many applications require individual adjustment of the speed or torque of various sections, and in such cases, the d-c Ward Leonard System is regarded as successful.

The variable frequency type of drive is, in general, similar to the Ward Leonard System, except that the requirements are for synchronization, or at most, a very small percentage of speed change between sections. From the beginning of the development of the polyphase squirrel cage and synchronous motors, it has been known that the ideal way to accomplish speed adjustment is to vary the applied frequency and voltage in direct proportion. The impedance of the motor circuit is directly proportional to the applied frequency, so as frequency is lowered, the reactance also drops. Now, if the voltage is held constant with decreased impedance, the motor current may increase to dangerous levels. Thus, when the frequency is to be changed substantially for speed control, it is advisable to provide simultaneous voltage adjustment.

Since the inductive reactance of an a-c motor varies directly with the frequency, the exciting current and torque would remain fairly constant with a

* Chicago representative of the Louis Allis Company of Milwaukee and the Dynamatic Corporation of Kenosha.

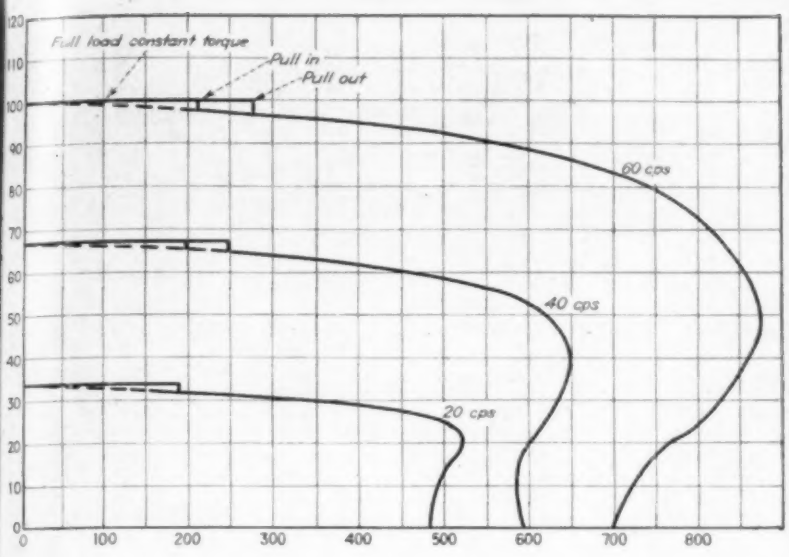



**Fig. 3 – Curves for three phase reluctance type synchronous motor. At all frequencies, this motor operates at practically constant speed over a wide range of torque values and is often employed in multi-motor drives.**

# Motor Drives

constant ratio of volts to frequency, were it not for the resistance factor. The resistance drop of the motor, primary and secondary, for practical purposes remains constant. Therefore, at lower speeds, the percentage of effective voltage remaining is less, so the torque is reduced and the speed regulation is greater. The lower the motor resistance can be made, the better the torque and speed regulation will be.

### Motors for Group Drives

The types of motors discussed below are suitable for adjustable frequency control. The characteristics of each are illustrated for purpose of comparison. It should be remembered that the values shown on the typical curves are for specific motor designs and can vary greatly with different motors. Furthermore, the characteristic curves, Figs. 1 to 3, show only the speed torque curves of the drive motors. The overall speed regulation of each system is discussed separately.

Squirrel cage motors are easy to apply, because a simple across-the-line starter can be used to connect or disconnect the motors at any frequency and voltage. Typical relationships between torque and motor speed are given in Fig. 1 for various frequencies. Comparison of these curves for a given value of torque shows that the drop in speed with increase in load is greater for lower values of applied frequency. The drooping characteristic is an advantage for applications such as conveyors, because the motors are inherently stable insofar as being able to maintain equal load division without adjustment. In other machines where the loads are steady and where it is desired to keep the units in synchronism, the motor characteristics can be matched at the factory so all motors will change speed about the same relative amount over the practical range of frequency.

Where the speeds of several individual units are to be closely synchonized the squirrel cage starting, d-c excited synchronous motor can be used. See Fig. 2 for a comparison of the speed-torque curves for various frequencies and voltage. In this motor also, the resistance factor of the a-c windings causes a reduction of pull-in and pull-out torque as the voltage is lowered, but the speed remains in direct proportion to the frequency. The starter for each motor consists of a line contactor for the squirrel cage winding and a timing relay, which short circuits the d-c field for starting at any frequency. After the motor is nearly up to speed, the timer removes the short from the field and applies d-c excitation, causing the motor to pull in and run as a synchronous motor, regardless of load variations.

The reluctance type of synchronous motor is similar to a squirrel cage motor except for slots milled in the rotor to produce the effect of salient poles. These motors have a high starting torque and are self exciting. Since the rating of a particular reluctance motor is only about one-third that of a squirrel cage motor in an equivalent frame size and since the high inrush current sometimes requires primary resistance starters, their application is limited to small sizes. From Fig. 3, a comparison can be made of characteristic speed torque curves at various frequencies for this motor.

Standard motor ratings designed for constant speed and frequency cannot be used in adjustable frequency drives without considering the heat dissipation at reduced speeds. Assuming 100% fan action at full speed, the ventilation at half speed is lowered to one-fourth. Therefore, on a constant torque basis, a larger frame might be needed to prevent overheating.

Adjustable frequency control, when applied to the above motor types, are principally suitable for group drives. Here, the simplicity of the control and the results obtained favorably balance the cost. An overhead conveyor or unit drive printing press, for example, may be driven by several squirrel cage motors at different points. All of the motors can be started and stopped together with a single control at the adjustable frequency source. In such cases, the squirrel cage motors are mechanically tied together by shafting; by the conveyor chains or belts; or, by the material passing through the machines. The motors inherently divide the load equally without adjustment and without being affected by temperature changes. However, if the driven sections are completely independent (have no mechanical tie-in), applications for group squirrel cage motor drives are limited to those where slight speed variations among units can be tolerated. Otherwise, synchronous motors should be specified.

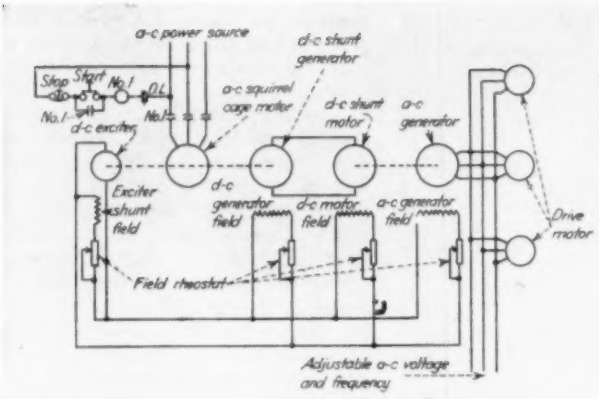



**Fig. 4 — Use of motor-generator sets to provide source of adjustable frequency for a multi-motor drive. This system performs satisfactorily but is costly, bulky and exhibits comparatively poor regulation.**

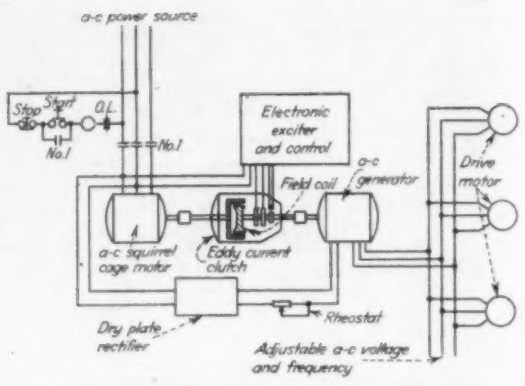



**Fig. 5 — Adjustable frequencies can be obtained from a squirrel cage m-g set by incorporating an eddy current clutch. Frequency of the generator output voltage is controlled by regulating the slip of this clutch.**

### Adjustable Frequency M-G Set

One means of obtaining an adjustable frequency and voltage, Fig. 4, consists of an a-c motor driving a separately excited d-c shunt generator. This motor-generator set furnishes variable voltage for a d-c drive motor, coupled to a separately excited alternator. The voltage and frequency output of the alternator is in direct proportion to its speed.

Several disadvantages are apparent in this system which have limited its use. First, the speed regulation of the motors is affected by the summation of the regulation of all the machines in the system. This can be improved by using a synchronous motor on the first motor-generator set, which also has the effect of improving power factor. Another factor is that the initial cost is necessarily high because of the number of machines and their controls. The efficiency is low, but this is usually of minor consideration as compared to the advantages in certain processes. In addition, a large amount of valuable building space is required to house the generating equipment. Lastly, considerable maintenance is involved, especially when additional equipment is installed to improve the overall speed regulation.

A speed range of about 8:1 can be obtained by operating the d-c generator field rheostat. Where all motors are to be started simultaneously, frequency and voltage can be built up from zero for smooth acceleration.

### Adjustable Speed Clutch

In recent years, eddy current slip clutches and brakes with electronic excitation and control have been developed so they can be applied over a wide range of speeds and torques with good speed regulation. The air cooled types are available in sizes up to 75 hp with integrally mounted squirrel cage motors. For larger sizes, water cooled clutches up to 5,000 hp are built, which can be direct coupled to either squirrel cage or synchronous motors.

A variable frequency generator set, similar to the one just described, consists of a squirrel cage motor, direct coupled to an eddy current clutch. The clutch, in turn, is direct coupled to the alternator. The other equipment required includes a motor line starter; separate excitation for the alternator; electronic exciter for the clutch; and the small alnico generator. A comparison of the elements of this system, pictured in Fig. 5, with those of the equipment illustrated in Fig. 4, discloses that the eddy current clutch dis-

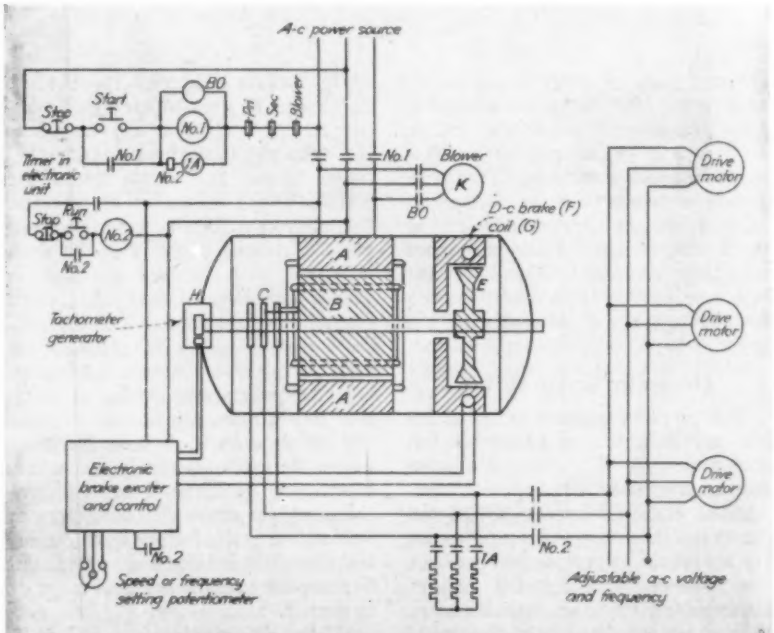



**Fig. 6 — A special design of frequency converter is a convenient power source for multi-motor drives. Only one machine is required, so this equipment is compact and provides good speed regulation over wide load range.**

places the two d-c machines. Speed control of the alternator is governed by a tachometer voltage which is fed through the electronic unit to control the grid of a thyratron tube. The thyratron in turn, excites the clutch field with just the right amount of voltage to maintain the shaft speed at the selected value regardless of changes in load or the slight variations of input speed that is caused by the changes in the slip of the squirrel cage motor.

The amount of power for the clutch excitation varies from a maximum of 200 watts for ratings up to 25 hp and 400 watts for ratings up to 150 hp. This is not a large factor in efficiency. A comparison of the two systems indicates that, above 50% speed, efficiency favors the clutch and, below 50% speed, it favors the d-c drive.

Speed regulation of the clutch-controlled system is much better than that of the d-c drive, particularly at the higher speeds. Speed variations of 10 to 15 rpm are sufficient to cause clutch coil voltage corrections from zero to full excitation. Therefore, at high speeds, the frequency regulation would be plus or minus one percent or better, and about ± 7% at the low range of 8:1 reduction.

### Adjustable Frequency Converter

The induction frequency converter is a wound rotor motor with a primary or stator winding connected to a three phase source of constant a-c voltage and frequency. The secondary or rotor winding is connected to slip rings. From these rings can be obtained frequencies lower or higher than the source. If the rotor is free to turn and the rotor circuits are completed by placing a load across the slip rings, the machine operates as a motor. Should the rotor be held stationary, a voltage is generated across the slip rings by virtue of the rotating magnetic field set up by the stator windings. The frequency of this generated voltage is the same as that of the source of the primary voltage.

Frequencies higher than those of the power source can also be obtained from the converter. This is done by driving the rotor in a direction opposite to that noted when the converter was run as a motor. The frequency across the slip rings is then a function of the speed of the rotating magnetic field in relation to the rotor. The secondary frequency of such converters can be varied by changing the operating speed by using a multi-speed or adjustable speed driving motor. Or, if the converter is belt driven, the frequency can be adjusted by changing the pulley ratio. In this way, several different frequencies are available from the same converter to adjust the speed of motors that are connected across the slip rings of the converter. If two different ranges of higher frequencies are required, the frequencies can be provided by two converters powered from the same driving motor. Or two converter sets may be used.

When the rotor of a frequency converter is retarded so that it operates at speeds less than its rated speed as a motor, the secondary frequencies across the slip rings are less than line frequency. At zero rotor speed the secondary frequency is equal to line frequency and the voltage is maximum. The magnitude of this voltage depends on the ratio of primary to secondary windings. If the rotor is permitted to come up to speed, both frequency and voltage decrease in direct proportion to the slip speed or the difference between synchronous and rotor speed. When a load is connected to the slip rings, the current in the rotor windings develops a motor torque that tends to speed up the rotor. A motor drawing its power from the slip rings of the converter represents a varying load that affects the torque developed by the converter rotor. Such torque fluctuations, if uncontrolled, lead to variations in the voltage and frequency available at the converter slip rings. The motor or motors powered from these slip rings would be subject to unstable operation as a result of the varying voltage and frequency. To avoid this situation, it is necessary to exactly balance the motor torque in the converter at all times by means of an infinitely variable controlled braking on the rotor shaft.

The relationship of the elements which make up such a machine can be described by reference to Figs. 6 and 7. The frequency changer stator is shown as *A*, the rotor windings as *B* and the slip rings as *C*. On the shaft extension at one end of the machine is mounted the eddy current brake drum, which rotates inside the stationary field member *F*. This member carries the excitation coil *G*. On the opposite end of the machine is mounted the tachometer generator *H*, which generates a voltage and frequency in direct proportion to rotor speed. The signal voltage from this generator is balanced in the electronic control against the reference voltage determined by the position of the speed setting potentiometer *K*. The difference between these two voltages, acting on the grid of a thyratron tube rectifies, a proportionate amount of a-c power from the line and feeds a variable d-c voltage to the brake coil. This produces a braking torque that always exactly balances the motor torque. If the converter starts to speed up as load is added, the slip ring voltage increases, resulting in stepped up braking torque. Similarly, a decrease in load causes a proportionate drop in braking torque. The conver-

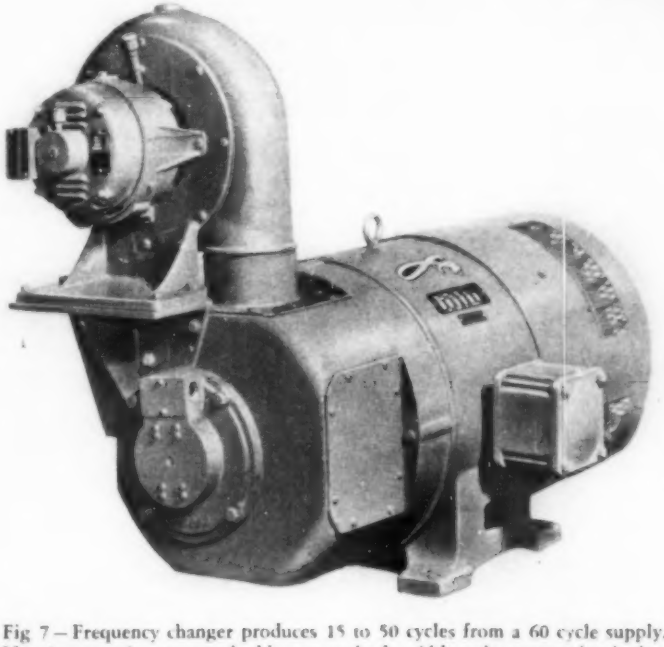


**Fig 7 — Frequency changer produces 15 to 50 cycles from a 60 cycle supply. Housing contains rotor and eddy current brake. Although construction is similar to that of a wound rotor motor, it performs as a rotating transformer.**

ter described can, of course, provide only frequencies below that of the line since the rotor is not driven by an external motor.

A speed change of only 10 to 15 rpm causes enough voltage change in the tachometer generator to alter the brake excitation from zero to maximum with an infinite number of intermediate voltages for maintaining a balance between motor torque and braking torque.

For a given constant torque or secondary current, the copper losses of the rotor and stator remains practically constant over the entire range of speed. The stator iron losses are substantially constant under the same conditions. The rotor iron losses will change slightly as the frequency changes. However, this is a minor loss. When operating at high speed, the motors are receiving high voltage and frequency, the motors are developing high horsepower and the changer is rotating at relatively slow speed. At reduced motor speed, the horsepower output developed decreases in direct proportion to the frequency and voltage. To provide these conditions of voltage and frequency, the frequency changer speeds up proportionally. The power drawn by the motors comes through the changer by transformer action. Thus, the frequency changer is essentially a transformer with a rotating secondary.

Since for a given torque, the secondary and primary currents remain constant, it is found that the primary power input to the changer remains practically constant. However, the product of volts, amperes and power factor of the secondary is a variable, depending on the voltage. The difference between power input to the changer and the power received by the motors (minus changer copper and iron losses) must be absorbed by the brake. The mechanical power absorbed by the brake is converted into heat at the surface of the brake drum as a result of the eddy currents generated in the iron. These losses are proportional to the slip speed and flux through the air gap for a given torque. At high rotor speeds the heat dissipated by the brake is a maximum, and this loss decreases in a straight line to a minimum at low speeds within the practical range of operation. The heat thus dissipated by the brake is the same as would result from resistors in the secondary circuit of a wound rotor induction motor under the same torque and speed conditions.

The usual self-ventilating fan on rotors of constant speed motors are ineffective on a frequency converter because of the rapid reduction of air moved as the speed decreases. From the previous discussion, it is seen that the copper losses of the a-c windings are practically constant and the brake converts into heat all the power that is not used by the drive motors. To insure adequate ventilation under all conditions, a motor driven forced ventilating fan is mounted at *K*. On units over 75 kw, the economy of space and first cost warrants the use of a water cooled brake, direct coupled to the converter.

The control for such a system is relatively simple as illustrated in Figs. 6 and 8. For starting the converter, primary contractor No. 1, Blower Starter (*BO*), and secondary contractor No. 1A with a small bank of resistors are required. The timer contact in the secondary contactor coil circuit, No. 2, prevents setting up the power circuit to the drive motors until the electronic tubes have been warmed up and the changer is up to speed. Depression of the start button simultaneously closes the No. 2 power circuit to the motors at low frequency and low voltage; drops out contactor No. 1A to disconnect the starting resistor bank and energizes the electronic exciter circuit to the brake. The speed setting potentiometer *K* meanwhile can be left at any desired pre-selected speed. The brake immediately receives full excitation to slow down the changer and speed up the motors until the voltage from the governor generator *H* balances the voltage set on potentiometer *K*. At this point, the brake excitation is automatically changed to the right value to maintain the speed desired. This method of starting brings all motors up together smoothly at a rate which can be governed in the electronic exciter.

Sometimes it is desirable to be able to start and stop each motor individually. In this case, individual across-the-line motor starters can be provided. So long as one or more motors are connected to the changer to provide sufficient load to rotate the converter, any of the other motors can be thrown off or on at the pre-selected voltage and frequency, at will. Of course, if no load is connected across the rings, the rotor circuit is open.

The overall speed regulation of such a system is good because only the regulation of the converter must be added to the motor regulation. Where d-c excited synchronous motors are used on the line, they can be over-excited to improve power factor which results in better secondary voltage. At lower frequencies where the squirrel cage motors have poorer speed regulation, the resistance factor can be offset by automatically connecting booster transformers in the converter secondary to increase the voltage without changing the frequency. Boosters also improve the torque on all types of motors and permit a wider range of speed adjustment than the usual three or four to one range.

The converter system requires only one main two bearing machine, which normally rotates at relatively slow speed, and a simple compact control. This is important from the standpoint of initial cost, building space required to house the equipment, and maintenance.

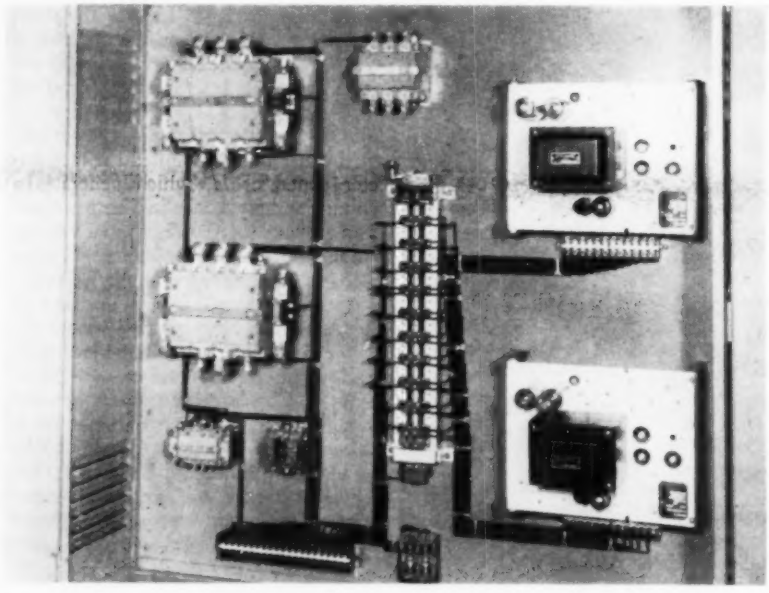
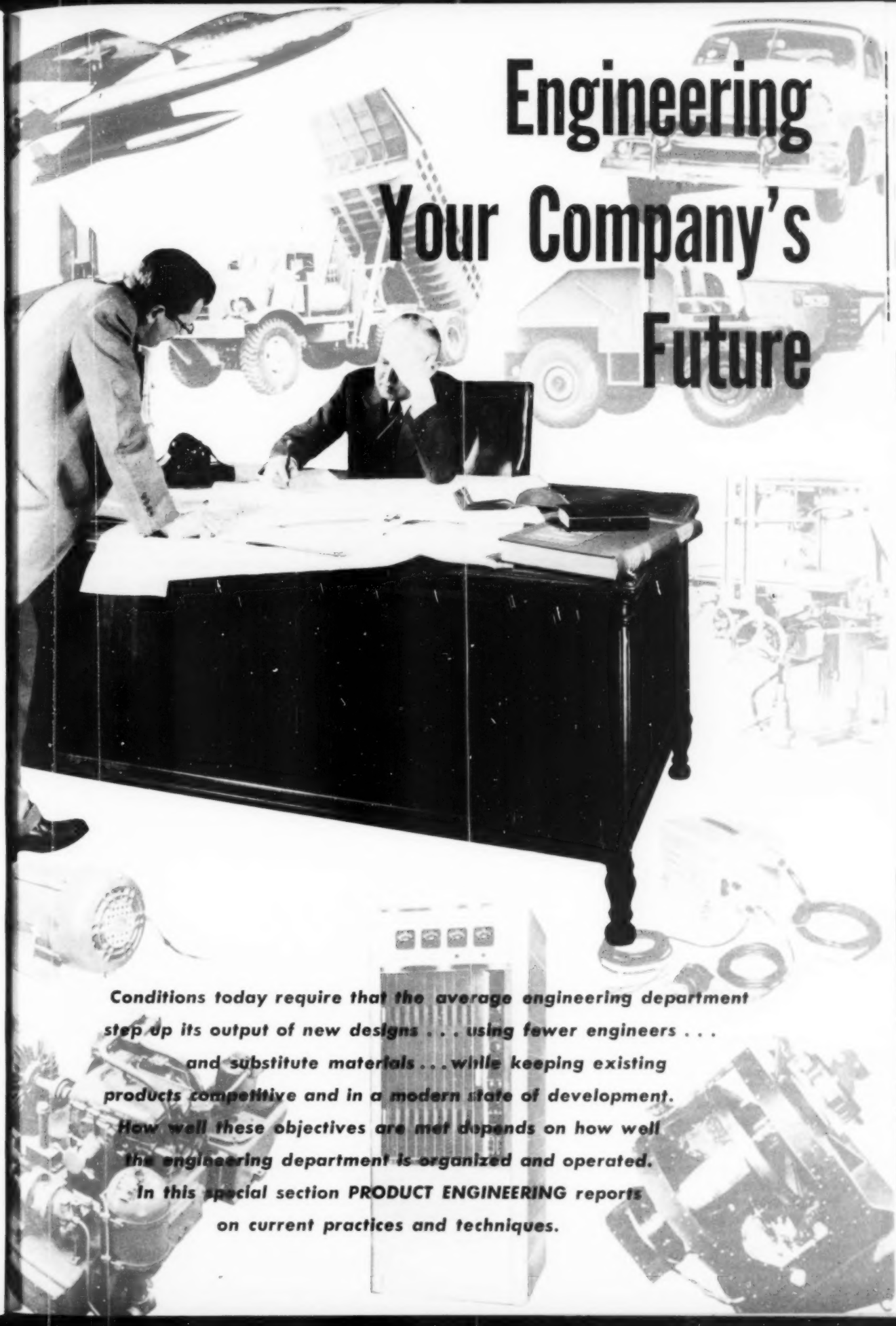


Fig. 8 — Main control for frequency changer of group drive. This includes electronic control for eddy current brake with emergency switch for spare exciter.



# Engineering Your Company's Future

***Conditions today require that the average engineering department step up its output of new designs . . . using fewer engineers . . . and substitute materials . . . while keeping existing products competitive and in a modern state of development. How well these objectives are met depends on how well the engineering department is organized and operated. In this special section PRODUCT ENGINEERING reports on current practices and techniques.***

# Essentials of Engineering Management

Known objectives and policies supported by an adequate budget
Suitable organization structure with definition of responsibilities and authority
Staffing of positions with engineers of adequate capacity and training
Establishment of suitable working conditions and facilities
Provision of effective systems and control procedures

**STATES M. MEAD**, Principal, Cresap, McCormick & Paget, Management Engineers

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ENGINEERING A COMPANY'S FUTURE involves many elements, but none more essential than the continuous provision of strong and sound engineering activity within the company. Throughout the manufacturing industries, in particular, the engineering function generally holds its company's future in its hands. However, this fact passes unrecognized by many corporate managements, and frequently even by engineering personnel themselves.

Corporate top management, which is often derived from the sales, manufacturing or finance divisions, too generally fails to sit down with the engineer and gain an understanding of his problems. Presidents and chairmen of the board are sometimes the worst offenders in failing to cause top management to indicate specifically to the engineering organization "Here's what we're shooting for this year, next year, ..... and here's what we expect of our engineering function."

At the same time, engineers have invited many of their troubles through negligence or reticence in applying to their own activities some of the principles of scientific management that have proven so beneficial to other functions of a business. Several postwar surveys have indicated that in only a minor percentage of industrial firms today is the engineering division or department organized and administered with adequate regard for acknowledged principles and practices of sound modern business management. Yet, perhaps never in the industrial history of this nation has there been a greater advantage to be gained by, and a greater need for, engineering management of the highest order.

Renewed attention to management of the engineering function has been made necessary by the tremendous forward rush of technical knowledge in the post World War II period. The war-born advances of the 1940's have been left behind by the competition accompanying expansion of our civilian economy and by the stimulus of rearming for defense, Fig. 1. There is literally no field of engineering in which great strides have not been made. All this has meant increased importance for the engineering function in most companies and, in many, has forced expansion of engineering activity in both breadth and depth.

While top management is becoming increasingly dependent upon engineering, the latter is becoming increasingly complex, to the point where few top executives can really understand what their engineers are

**Table I — Check List of Requirements for Engineering Policies**

**Are the policies of your engineering organization**
- ✓ Generally known
- ✓ Uniformly understood
- ✓ Consistent with overall policy
- ✓ Applicable to engineering objectives
- ✓ Adequate in scope

**Do they provide sufficient guidance for determining specific plans and formulating standard procedures with regard to**
- ✓ Organization of the engineering function
- ✓ Research and development programs
- ✓ Utilization of outside research agencies
- ✓ Relations with inventors
- ✓ Test programs and the use of models
- ✓ Use of outside test facilities or consulting services
- ✓ Design standardization, including parts and materials
- ✓ Design change
- ✓ Patents and licensing agreements
- ✓ Customer technical liaison
- ✓ Planning, scheduling, estimating and control of work
- ✓ Engineering personnel administration
- ✓ Engineering drawings, reproduction and release
- ✓ Security of confidential information
- ✓ Facilities and working conditions

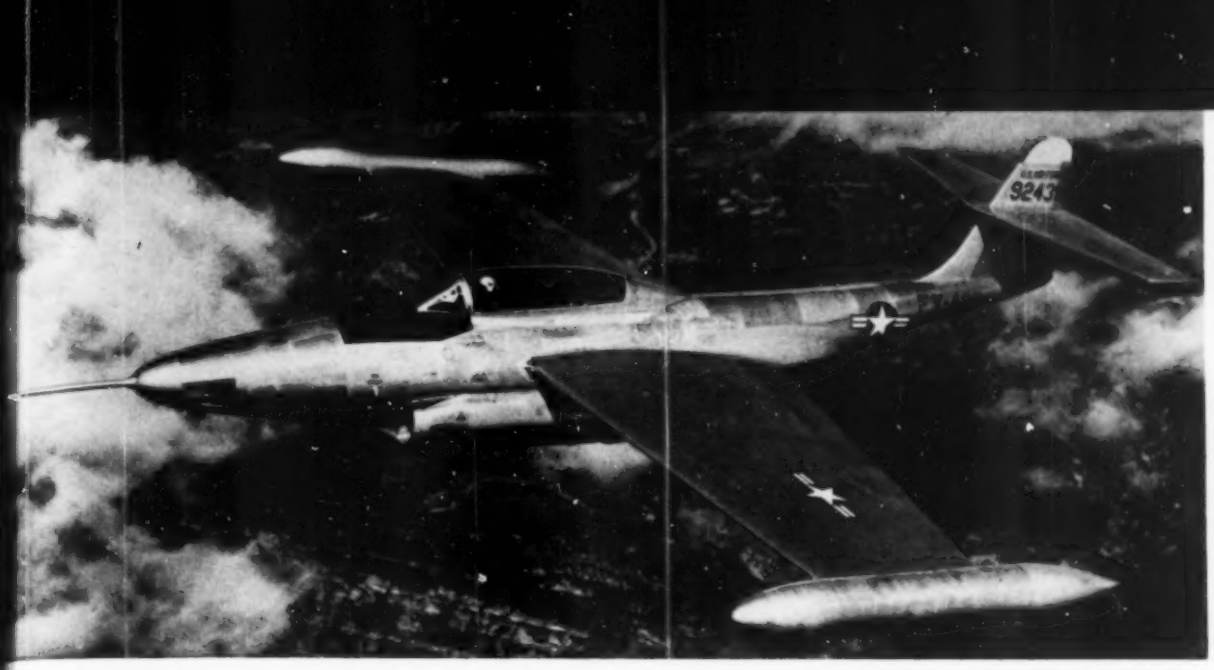


**Fig. 1 – Rapid advancement of technical knowledge is evident in most all engineering fields. Northrop F-89 Scorpion, all-weather interceptor mounts two late-model Allison jet engines that produce speeds in excess of 600 miles per hour.**

talking about. Problems are arising by reason of increased numbers and greater complexity of projects, and higher research and development costs. And the Defense Program is adding misery to woe because it takes top engineering time and energy away from normal competitive business.

A typical case is that of a company which throughout 1946 had an average of three major developmental projects in progress, involving essentially only one field of engineering. Throughout 1952 this same company will have an average of seven major developmental projects in progress, involving two, and often three, different fields of engineering, and a budget six times that of 1946.

The problems referred to above cannot be overcome merely by employing greater numbers of engineers, notwithstanding a natural tendency for the engineering executive to seek a solution by this route. There is a seriously harmful shortage of trained engineers and, this situation is worsening. It is therefore essential that more effective use be made of available engineering talent.

Fortunately, many phases of these problems can be overcome by harnessing a company's existing engineering capabilities with a sound organization structure and, through efficient management practices, directing engineering efforts toward established objectives.

## Objectives and Policies

To those engineers who dread even the slightest mention of administrative functions, a reference to "objectives and policies" will be an anathema. Yet, without known objectives, policies (Table I) to govern administration of effort toward them, and a realistic budget in their support, the engineer is handicapped.

The broad objectives of engineering and research are threefold: (1) To provide a product of maximum utility and value in relation to a price that gives a profit; (2) to maintain the company's competitive position from an engineering design standpoint; and (3) to achieve economy in manufacturing to the extent that it depends on good engineering. However, aims less broad than these are necessary.

Presumably, the engineering executive cannot plan his organization, his personnel needs or his facilities requirements unless he has identified more specifically his objectives in terms of the character and scope of the research and engineering effort to be undertaken. Budgetary expansion in personnel or facilities would seem unwise without a planned objective. Yet, the chief engineer of a large company in one of the major industries recently bemoaned his situation with the statement "Our planning can hardly keep up with our expansion." He was expanding his engineering division with nothing more than a short term objective and with almost no policy mandates from top management.

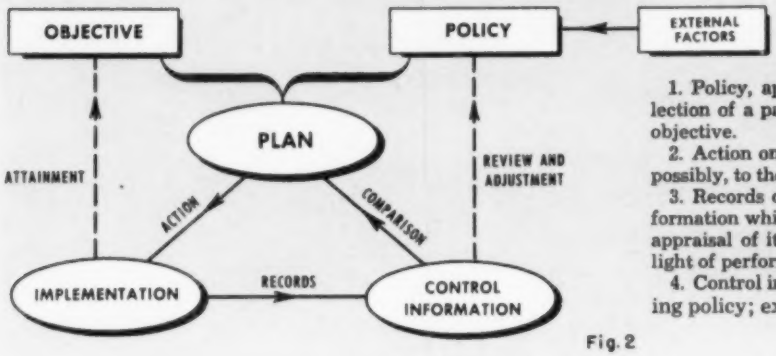
Certainly, neither research nor design projects can be established logically if the objectives are not known and the governing policies set. Questions such as the following will be left unanswered: Should we design to utilize existing facilities or beyond, present manufacturing experience or beyond, present or new sales force? In addition, there can be no assurance that all developmental work undertaken is justified, or that due consideration is given to new ideas. And, procedures planning cannot be efficient under such circumstances.

A prerequisite to sound objectives, policies and budgets for research and engineering is, of course, the existence of known company-wide basic objectives and supporting policies. These basic objectives should identify the long range aims of the company with respect to the character, size and profitability of the business. The supporting basic policies should establish principles to govern the conduct of operations toward the objectives, as for example, policies with respect to diversification or simplification of product lines, government business, plant investments and personnel relations.

When basic objectives are not set by top management – the Board of Directors, the Executive Committee or the chief executive officer, there is a tendency for the engineering function to develop company objectives as a natural result of the application of its analytical and creative brains in research and development, and of its ability to design a marketable product.

Thus, the company's basic objectives come to be determined more by chance, through the research and design initiative of its engineering

THE INTERRELATIONSHIPS OF OBJECTIVE, POLICY AND PLAN




1. Policy, applied to a defined objective, governs selection of a particular plan to be used for attaining the objective.
2. Action on the plan leads to its implementation and, possibly, to the attainment of the objective.
3. Records of the implementation provide control information which, when compared with the plan, permits appraisal of its execution and a review of policy in the light of performance.
4. Control information may force adjustment of existing policy; external factors also may force a change.

Fig. 2

organization rather than by the considered judgment of its top management.

Engineering's unpublicized challenge is administration, the fundamental tool of which is policy. Table I lists requirements with respect to engineering policies which, of course, should be consistent with those of the company as a whole; and to this end, it is necessary that overall company policies be known. Actually, engineering policies are principles or attitudes formulated for the purpose of guiding and governing the future decisions and actions of the engineering function.

When the various engineering objectives are known, plans and programs can be developed to achieve them. However, the selection of each particular plan, from the many that might be developed, should be governed by approved engineering policy. This, of course, stresses the importance of policy formulation, which is probably the most significant of all administrative responsibilities to be discharged by the engineering executive.

Finally, engineering policy should be expressed if it is to be known and satisfactorily interpreted. The means of expression most frequently used is that of the engineering policy manual. Such a manual, however brief it may be, enables persons both inside and outside the engineering function, whose work is concerned with action to be taken or decisions to be made in the engineering field, to know the company's stated policy with respect to a particular engineering question. In companies with a very small engineering department, the same end can be achieved through a common understanding of engineering policy by the few persons concerned. However, this is satisfactory only as long as policies are conveyed verbally and the working relationship is close.

### *What Engineering Objectives?*

Engineering objectives should include separate and distinct research objectives, product design objectives, and service engineering objectives.

*Research objectives* should indicate the relative attention to be given pure research as distinct from applied research, where both are involved. Generally, management should sponsor both basic research and its commercial application in appropriate balance to the nature of the business. These objectives should also indicate the accent to be placed on particular subjects within each type of research for the period ahead.

Objectives in some companies may extend to reduction of cost or raising of quality through research in the control and improvement of highly technical processes. This is true of companies in the chemical or steel industries, wherein chemistry and physics are predominate elements.

It is of utmost importance that there be research objectives, for without them there soon comes to be no research. The immediacy of current design and service engineering requirements tends to displace research activity unless the latter can be justified by an established objective. Similarly, unless research objectives are supported by an adequate and specifically allocated budget, their attainment is seriously jeopardized.

*Product design objectives* should be more immediate and more specific than research objectives as regards the maintenance or improvement of a company's competitive position from an engineering design viewpoint. As a guide to the engineering organization that must accomplish them, these objectives should be spelled out as specific product design aims. They can be expressed in terms of desired improvement in the utility, quality, style or cost of the product. They should indicate any projected additions to the models or sizes in existing product lines. And they should take into consideration the types and amount of equipment to be available for the manufacturing processes involved.

A company's product engineering objectives should also take cognizance of the defense program and the existence of materials shortages. This may lead to simplification of product lines and standardization as immediate engineering objectives, and to the weeding out of old products. Parts standardization may also have a place among the product engineering objectives of a company.

Appearance design should not be overlooked in the determination of objectives for the improvement of product design. Its impact on the style and, consequently on the sales of many consumer products, is appreciable.

*Service engineering* is the third category of engineering effort for which the objectives should be properly identified. Facts gleaned from service engineering experience provide the basis from which many research or product engineering objectives are developed and the importance of having well considered objectives in terms of character and coverage cannot be overestimated.

Generally, this means that the desired nature or character of the service engineering must be determined, along with its scope in terms of field coverage. Due consideration of past experience, recommendations from the sales organization, customer correspondence, and customer plans should govern formulation of service engineering objectives.

### *What Engineering Policies?*

Engineering policies encompass a wide range of elements falling within the scope of research, product and

Ford Motor Company

**Fig. 3 – Design objectives can include improvement in a product's styling or assembly through the use of pilot models.**

Ford Motor Company

**Fig. 4 – Engineering policy fixes relationship between research and design as typified by study of car riding qualities.**

service engineering activity, and include the various administrative services conducted in support thereof.

*Research vs. Product Design and Service Engineering.* Perhaps of major significance is policy with regard to the relationship between research engineering on the one hand, and product design and service engineering, on the other hand. Are they to be consolidated organizationally, or is it policy that research is to exist as a clearly separate function within the engineering family? Will a section of the organization be devoted to the service engineering activities, or is the pressure of such activities to be allowed to divert time and attention from design engineering, and both to claim attention at the expense of research? To what extent will the same engineering personnel be given responsibility for both research and current design change, for both production engineering and consideration of potentially profitable new ideas? These are some of the questions to be answered by engineering policy.

The recommended policy is that which guarantees the life and effectiveness of the research function, and thus insures the company's future. Such policy calls for the fixed determination of a research budget and a clear delineation between research and other engineering activities.

Research budgets can be set as a percentage of (1) the company's capital investment, (2) the normal capacity of its plant, or (3) the average annual sales for a number of preceding years. Those who relate the research budget to sales are using from about 2.5 percent to as much as 5 percent, the latter in the chemical industries. However, any tendency to have the research budget governed essentially by last year's sales or profits should be avoided, since an expenditure for research may be most appropriate at the very time when current business is poorest.

Budgeting in spurts for research is also to be avoided as wasteful since it prevents the scientific conduct of research and precludes continuity. Whatever is budgeted should be firmly committed and spent wisely, preferably in that year, and any surplus used to supplement the succeeding year's research budget.

To the maximum extent practicable, depending on the nature of the business and the size of its engineering organization, the research function should be operationally apart from product and service engineering. By this is meant that it should share neither the same engineers, the same working supervisor, nor the same immediate space with the part of the engineering organization that deals mainly with day-to-day problems, design change notices, service, and government regulations on current production and existing models. This latter activity must be conducted on what might be termed a "fire brigade" basis, putting out the fire of immediate situations. Research must be free of such distractions. Engineers themselves are by nature and training qualified differently with respect to the types of engineering mentioned, and should be assigned accordingly, whenever possible.

Lastly, it is sometimes wise to provide a clear degree of physical separation between the research engineers and those engaged in the other aspects of engineering activity. This may mean location in widely separated cities, as is the case with many large corporations or it may mean the use of no more than a curtain or screen as a shield from distraction and a visible line of demarcation between research and other engineering areas. When such separation is not dictated by policy, much time is wasted regularly by engineers whose natural curiosity and professional interest are drawn by the very presence of technical activities other than their own. In addition, it invites the bogging down of research in non-research details.

*Specialization.* There is also policy regarding encouraging or allowing engineers to specialize within the research engineering function itself. Wherever feasible this sort of specialization should be encouraged, since in no other phase of organization does it give greater returns than in the field of engineering research and design.

Research policy should indicate the extent to which product development is to be generated from among employees or outside inventors, as distinct from within the research organization. Both avenues of origination are vital. To rely only on that stemming from employees and inventors would mean having a "hit and miss" result; to rely on the research organization alone would mean to suffer the practical loss of ideas from the other source.

*Contacts With Outside Services.* Definite policy is needed to govern relations with inventors, with outside research agencies and with facilities, test or advisory services. Will inventors' projects be handled as secretive, mysterious operations and established as rump activities outside the normal organization? Preferably not, for many thousands of dollars are squandered annually through such a policy. If an inventor's scheme or device is one justifying serious study, it should be fitted into the company's research, product design or service engineering function. If

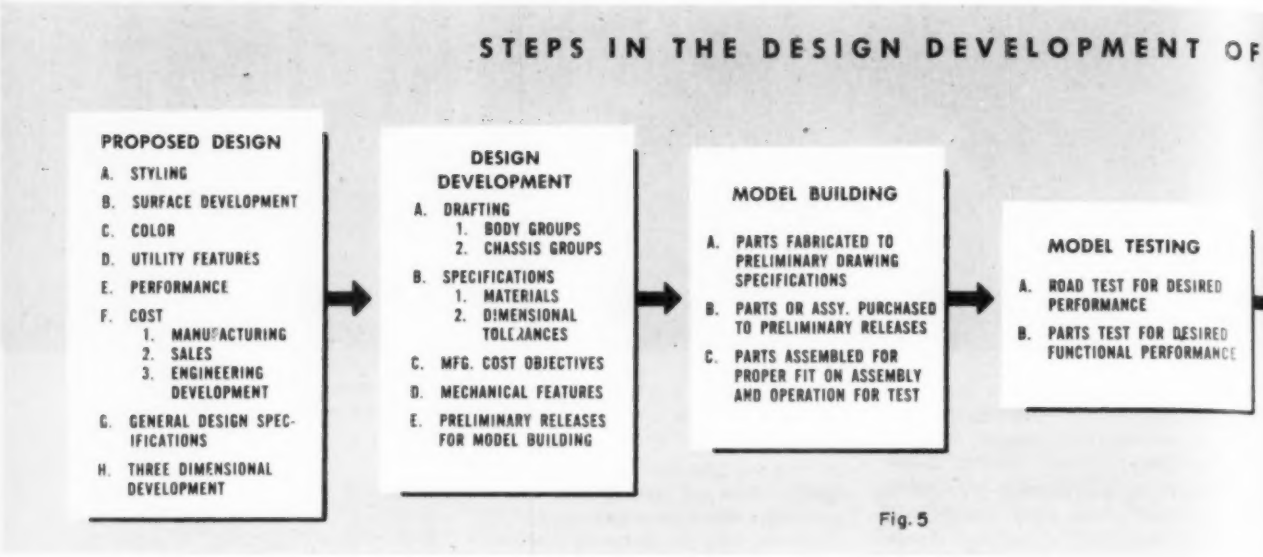



Fig. 5

the company is serious and has full confidence in the man, and he in it, then there should be no reason to withhold disclosure of the inventor's project within the company.

With respect to engaging additional research or general engineering service through outside agencies, a company's policy should require that first consideration be given to expansion of its own activities, so as to retain for itself the benefit of knowledge already gained. On the other hand, the use of outside engineering firms for special research, development or test services is a standard policy for many companies whose activities would not justify the acquisition of permanent facilities and staffing for these purposes. Engineering departments frequently call upon IBM or other agencies for the solutions to complex formulas by means of an electronic "brain," or analogue computer. In addition, industry makes beneficial use of advisory and test services available in such fields as metallurgy, electronics, instrumentation, chemistry and physics. Policy should make clear the extent and the conditions under which such activities as the Armour Research Institute or Battelle Memorial Institute might be engaged for professional services.

*Test Programs.* What type of tests will products be given and how are they to be given? Will the company endeavor to maintain a complete testing laboratory or will it anticipate utilizing an outside organization. In either case, to what extent are the reliability and validity of laboratory tests to be checked by test in the field?

Field tests can be performed in various ways. The major automobile manufacturers maintain large proving grounds and testing laboratories for the purpose; a small company might merely place its product in service within the normal operations of its organization where it would be handled by persons of varying skill. From a policy standpoint, it is often wise to give good experimental products to prospective customers free of charge for field testing in their equipment. This generally has the effect of promoting good-will, since potential customers are eager to try a newly developed item which might prove advantageous for incorporation into their standard equipment. A policy of furnishing free samples of a new development to prospective customers for test in their equipment can be beneficial both to the company and the customer.

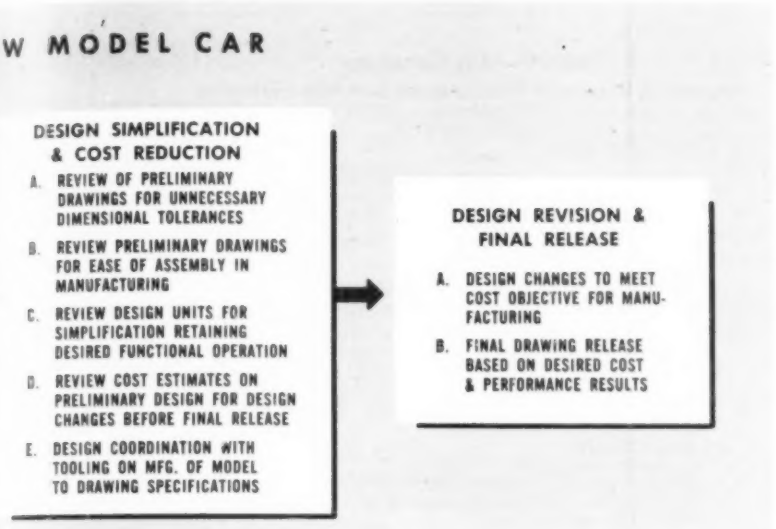
As a matter of policy, field testing should not be applied to preliminary designs. This is especially true if the intrinsic value of the test component is small in relation to the value of the device in which it is tested, since a failure of the item may cause serious damage to the machine or personnel doing the testing. Furthermore, it is unwise to use potential customers for field test when there is a chance of having a number of unsuccessful runs and consequent loss of the customer's interest in the development.

*Standardization.* This is a worthy object of engineering policy because design standardization and simplicity can contribute much to cost reduction. Purchasing can be facilitated, volume discounts obtained and variety of inventory reduced, when the engineers follow a policy of standardization on certain parts and materials. Costs and delays are reduced when policy dictates that the engineer's specifications conform as thoroughly as possible to those materials, parts and products known to be on the market.

*Interchangeability of parts* affords many advantages to the manufacturer as well as attractive benefits to the customer. Where circumstances allow, this should be sought as a matter of engineering design policy.

*Design Development and Change.* A definite policy regarding design development and change is of importance. It should form the basis for a positive and uniform approach to the development of a new model through the various stages from proposal to final release, as illustrated for a new model car in Fig. 5. Also, design policy is needed to identify the type of changes considered mandatory for immediate application to all subsequent production, as distinct from those changes that may be incorporated at a convenient point in the schedule, and the priority to be followed with the latter.

*Patents and Licensing Agreements.* In any engineering organization, an established and well promulgated policy with respect to inventions and patents is almost a necessity from the employee relations standpoint alone. With respect to licensing, it must be remembered that since large-volume users of small parts require for their own protection


EW MODEL CAR
DESIGN SIMPLIFICATION & COST REDUCTION
A. REVIEW OF PRELIMINARY DRAWINGS FOR UNNECESSARY DIMENSIONAL TOLERANCES
B. REVIEW PRELIMINARY DRAWINGS FOR EASE OF ASSEMBLY IN MANUFACTURING
C. REVIEW DESIGN UNITS FOR SIMPLIFICATION RETAINING DESIRED FUNCTIONAL OPERATION
D. REVIEW COST ESTIMATES ON PRELIMINARY DESIGN FOR DESIGN CHANGES BEFORE FINAL RELEASE
E. DESIGN COORDINATION WITH TOOLING ON MFG. OF MODEL TO DRAWING SPECIFICATIONS
DESIGN REVISION & FINAL RELEASE
A. DESIGN CHANGES TO MEET COST OBJECTIVE FOR MANUFACTURING
B. FINAL DRAWING RELEASE BASED ON DESIRED COST & PERFORMANCE RESULTS

more than one source, the manufacturer of such parts may be forced to adopt a policy of licensing others. This subject must be carefully thought through.

*Engineering Customer Liaison.* Policy with regard to engineering liaison with the customer is necessary if there is to be a satisfactory bridging of the technical minds in the producer and customer organizations. It is also needed to preclude giving any indication to the customer of overlaps or voids in responsibility and authority in a company's engineering organization.

Engineering policy, with due consideration for sales policy, must determine the nature of the technical service liaison to be furnished customers. This will govern procedures with respect to communicating service complaints and service-life data to the engineering department. It will determine, for example, whether a service publication will be issued periodically or otherwise, and in what form.

Policy with respect to technical liaison with customers and potential customers depends largely on the character of the product and the method by which it is marketed. It may encompass the subject of special courses of training for customer personnel. In all cases where the customers themselves represent or are represented by technical activities, the manufacturer's engineering policies must necessarily provide for there being effective, close liaison.

*Administrative Services.* Policy with respect engineering administrative services should encompass all the non-technical functions that support and service the substantive engineering efforts, including such principal elements as:

(1) Planning, scheduling, estimating and control.

(2) Personnel recruitment, selection, assignment, training and advancement.

(3) Reproduction, release and records, library and files.

The larger the engineering organization and more numerous and complex the products, the more need there is for expressed policies with respect to these administrative functions. In an engineering department of only a few individuals, administrative responsibilities can be centered in one person or shared by all. In either case, administrative policy as developed in practice comes to be understood by all, regardless of whether it is formally identified. However, when this small engineering function greatly expands its size, as many have done, conscious consideration must be given to the formulation, promulgation and interpretation of engineering administrative policies. Otherwise, as has happened in many cases, coordination and progress of engineering technical effort from project to project becomes hampered by inconsis-

**Fig. 6 – Elaborate facilities for testing complex parts and assemblies are generally found in the larger companies.**

Boeing Airplane Company

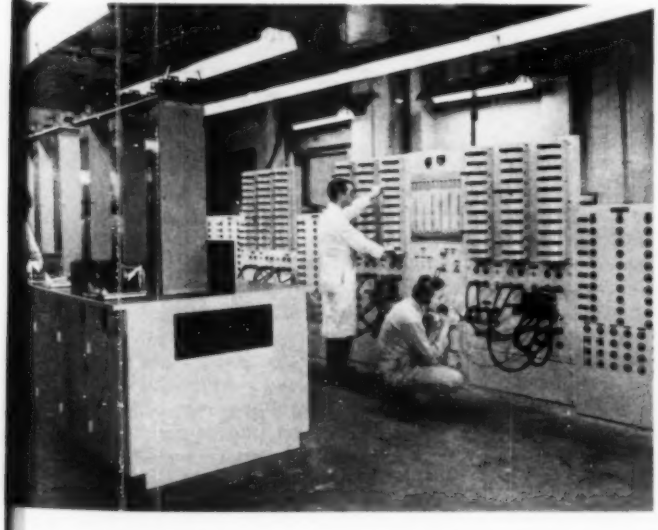


**Fig. 7 – Independent research organizations are of great value to companies when specialized problems must be solved.**

Battelle Memorial Institute

tent planning, incomplete scheduling and variable estimating.

The absence of expressed administrative policy on engineering matters also leads to the co-existence of widely different approaches to engineering progress control and cost determination. Planning effort is identified by many engineers as being unnecessary and a waste of time, especially since circumstances often call for revision of an established plan. However, planning and scheduling is feasible and essential to the development of sound estimates of time or cost. And, far from being impractical for complex or variable engineering projects, planning provides full and detailed visualization of the manner and extent to which engineering manpower, facilities and funds are being utilized.

Policy should dictate that engineering effort, including research, will be planned and scheduled to the extent practicable and that this planning and scheduling will be dynamic, and hence useful. Other policy questions might be: Should project estimates serve as a guide rather than a fixed limit or appropriation? Should they be tied in departmentally?

Personnel administration policy is particularly important insofar as the present-day engineering department is concerned. This is partly because engineers are in short supply, but even more by reason of their generally different temperament and higher-than-average educational level. Accordingly, there is both justification and need for an expression of personnel policy directed specifically at engineers, although conforming generally to overall company personnel policy. For example, policy should supply the answers to such questions as listed in Table II.

**Table II — Key Questions Regarding Personnel Procurement and Administration**

1—RECRUITMENT

Are engineers to be used for recruiting?
Are there any restrictions on employment of women engineers?
Are undergraduates to be considered for part-time or summer jobs?
Are non-graduates with some technical training and experience to be considered?
Should preference be given to local residents?
Are company representatives selected to keep in touch with engineering schools?
Can aliens be used in non-military work?
Will traveling expenses be paid to facilitate tour of plant and interview?
Is engineering recruitment separate from non-technical counterpart?

2—SELECTION

Are there to be pre-employment tests?
Is a physical examination required?
Are references checked?
Is citizenship required?
Should security check be made?
Is an engineering degree required?
Is it permissible to compromise on scholastic standing to fill quota or obtain other desired talents such as supervisory experience, special technical training, teaching ability or acquaintance with leaders in a given field?

3—ASSIGNMENT

Are aptitude tests to be used?
What policies govern initial assignment?
What principles govern subsequent assignments?
How are transfers handled?
Is an engineer immediately assigned to a specific job or made part of a pool for future assignment?

4—TRAINING

Is there any policy on indoctrination?
Is there specialized training other than by experience alone?
Is rotation through various departments encouraged?
Is specialization in one field emphasized?
Is off-the-job training encouraged and supported through financial assistance?

5—ADVANCEMENT

What is policy for supervisory training and executive development?
What principles guide performance appraisal and advancement?
Is there a policy for giving a preagreed raise at stated intervals?
What is policy with respect to recognition of achievement?

Recruitment and training policies are particularly significant at the present time. Without planned recruitment, a company may find it difficult to obtain an adequate number of engineers to handle increased work loads; and lacking a training program, a company may experience disinterest among staff members. If they know how pay scales are set up, how often job performance reports are reviewed and what the prospects are for advancement, engineers, like most employees, retain an interest in their work and continue to set goals for future attainment at a high level. A healthy morale is thus maintained, output per manhour increased, and a stabilized staff retained.

Finally, policies to govern engineering administration are not complete unless they provide adequate guidance with respect to the engineering drawing media to be used, the selection of reproduction methods, the determination of engineering release practices, the maintenance of an engineering library, and the preparation and retention of engineering records and files.

When many engineering organizations are engaged in defense work of a highly confidential nature, and the rest generally involved in very competitive research activities, there is no doubt but that a company's engineering policies also should include principles to govern communication and security of information. This might encompass policy with respect to participation in industry associations and professional societies. If management favors the presentation of technical papers or writing of articles for technical journals, policy should prescribe procedures for checking information to be thus released to insure agreement with general company policies and security regulations.

# Organization

***Position of Engineering in Company***

The position of engineering and research in a company's organization structure should normally be governed by the nature of its product or products, but may be influenced also, by the size of company and the technical background of its general manager. However, an underlying consideration in all cases is that the product engineer, if he is to be effective, must work closely with sales, purchasing, tooling and production (including shops).

If the character of a company's products is such that engineering, including research, is perhaps the fundamental factor in the ultimate success or failure of the business, these functions should always report directly to the executive who manages the overall operations of the company. This is true for all companies in highly competitive fields and with extensive need for research and design development effort. For them, a separate engineering and research division as shown in Fig. 8 is essential.

In companies making simple or standard products, engineering is of secondary importance and generally subordinated to the executive in charge of manufacturing. In such cases the major engineering requirements are not so much of the research and development type as of the tool design, processing, methods and plant layout type. Hence, there is unlikely to be a Vice President – Engineering or a Director of Engineering. More likely, there will be a Chief Engineer reporting to a manufacturing vice-president, as in Fig. 9 or to an executive carrying the title of Manager of Manufacturing, or possibly Director of Engineering and Manufacturing.

In companies where traditionally the Executive Vice-President or General Manager is a manufacturing man who participates mainly in directing the production activities, the Chief Engineer might report to that executive level even though the engineering functions are relatively simple and of minor importance. Under the same conditions, a Director of Research might also report to that level if research remains important despite being of secondary significance. In this case, he would be in charge of a relatively small staff department or section.

When a Works Manager or Plant Manager is, in effect, the general manager of a business, he may have engineering, purchasing, industrial relations and accounting functions under his jurisdiction. It has been observed that companies whose purchasing and industrial relations functions can be justified under the manufacturing executive are generally the ones whose engineering, also, is most effective in that organizational location. However, this parallel must be applied with caution and due consideration given other governing circumstances.

The value of basic research alone may be so paramount that the research organization should be established apart from the other engineering activity, and be directly responsible to top management. This is true in the case of Bell Telephone Laboratories, Incorporated, whose primary mission is research and development and much of whose research is basic.

Occasionally, the research engineering function is of such importance to a large corporation or group of affiliated companies that an auton-

**Fig. 8 – A separate Engineering and Research Division reporting to the operating head, such as the General Manager, is essential in the organization of companies where these functions spell the success or failure of the business.**

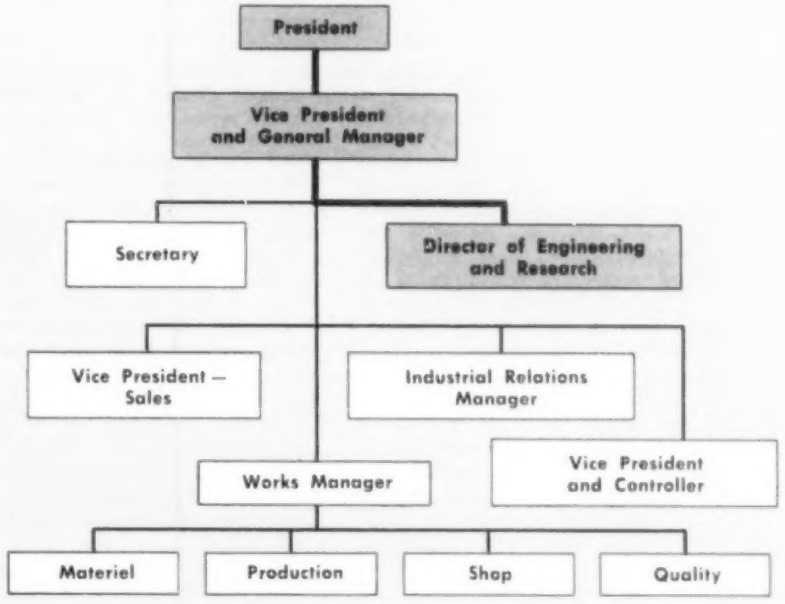
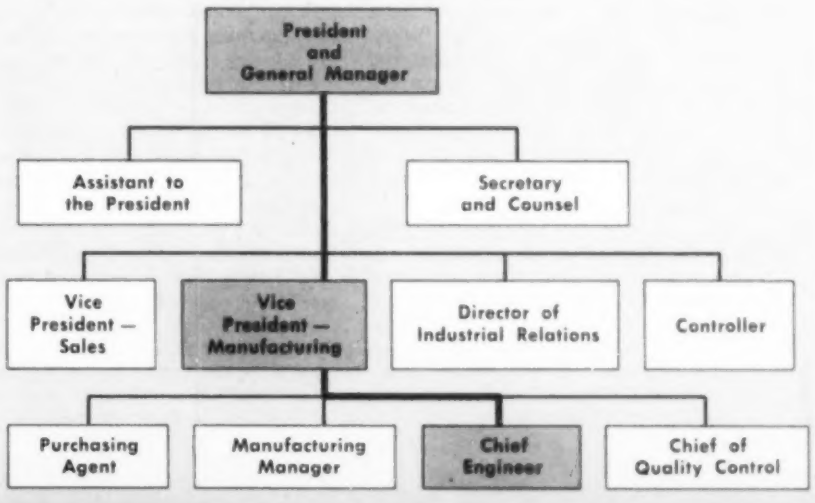



**Fig. 9–The engineering department in a company making simple products that require more emphasis on production tooling and processing rather than on research and design is generally subordinated to the manufacturing executive.**



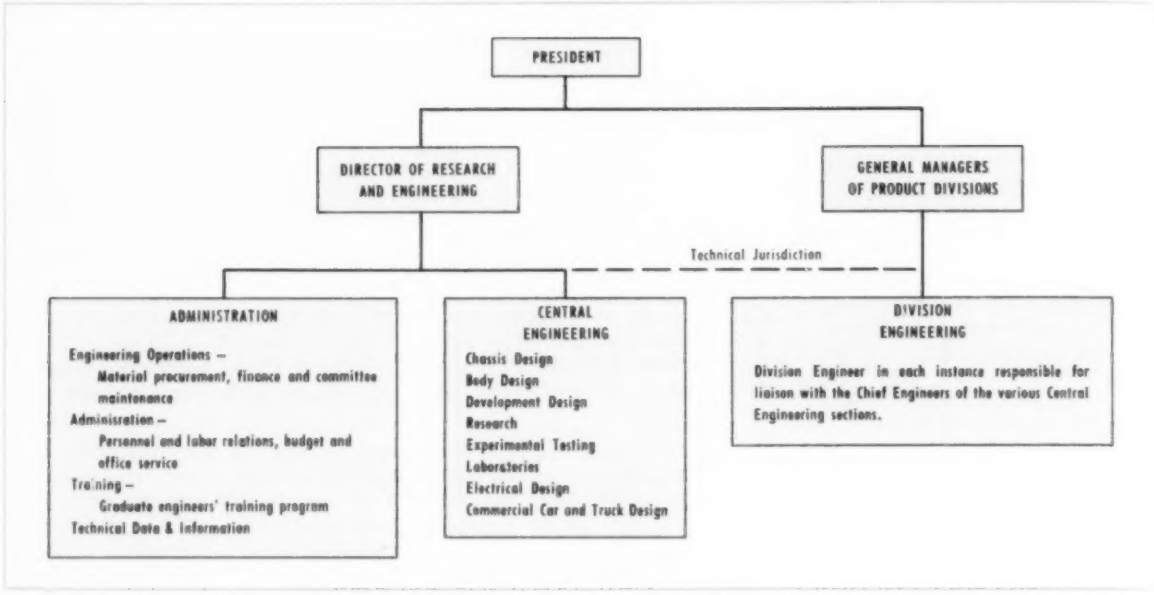



**Fig. 10 – A Centralized Engineering Section is well suited to a multi-plant company making various lines of similar products. Developmental personnel and facilities can thus be pooled at one spot to the advantage of all divisions.**

omous research company is established to serve them. This has been done in the oil industry, as exemplified by the Gulf Research and Development Company, a wholly-owned, non-profit subsidiary of the Gulf Oil Corporation which serves as a centralized Research Department for all the companies of the parent corporation.

Size of the company, in addition to nature of the products, should be considered in any determination of the position that engineering is to occupy in the organization. In the very large multi-plant and multi-product corporations, the engineering function appears at various levels and in various ways. Generally, the larger the company, the more desirable it will be to organize the engineering responsibilities away from manufacturing, thereby simplifying the administrative function. In such cases, however, care must be taken to prevent the engineers from retiring, so to speak, into an "ivory tower" and being too far from the manufacturing function to understand its problems with respect to processing and methods, and perhaps too far from the sales function to understand customer needs. This danger can be avoided through liaison and coordination achieved by firm top management policy and supervision, and by inter-functional committees.

The chart, Fig. 10, illustrates in simplified form the engineering relationships in a multi-plant company where product lines are so similar as to warrant an extensive Central Engineering organization of some 3,000 technical personnel, with proportionately smaller engineering staffs in the product divisions. This concentration of the company's development work has the advantage of providing in one place more and better facilities and talent than any one product division could afford. It has the further advantage of avoiding duplication of effort. This scheme of centralized-engineering organization cannot be applied to such advantage when dissimilar product lines are involved.

In a small company, regardless of the product, the executive overhead must be kept at a minimum. Furthermore, since more reliance must be placed on individual action, and very little on committee action, the relative positions of enginering and manufacturing in the organization structure should also take into account the qualifications of the top executive. If the general manager is an engineering or production man, the two functions can just as well report to him, since he should be able to coordinate them. If, however, his background is sales, finance or law, the general manager of a company will be wise to join the enginering and manufacturing functions at the organizational level below him. When such is the case and research is an element of particularly vital importance to the business, the research engineering function alone might be located separately as a staff section reporting directly to the General Manager of the company. In a small company there should be no problem of achieving close liaison between such a unit and either the manufacturing or the product and service engineering functions.

Job shop organization sometimes necessitates special consideration with respect to placement of the engineering function in the overall company organization. Fig. 11 portrays an effective organization for business on a job shop basis in a major product division of a large industrial corporation. Engineering functions are split between a General Engineering Department under a Chief Engineer responsible to the General Manager and a Job Shop Engineering Section under the Factory Manager and Job Shop Manager. Design control responsibility rests with the General Engineering Department. This is an instance wherein the engineering function is of critical importance, and for this reason, the individual who is the General Manager of the division is also serving as its Chief Engineer.

### *Organization of Department*

The structure of organization for engineering activity is frequently developed by expedient, layer on layer, inconsistently and incongruously, and with greater than the normal tendency to mold organization to individual personalities and idiosyncrasies and to avoid clear delineation

of responsibility and authority. In firms of small or medium size, this seems to have been the rule rather than the exception. Only in the very large companies can one be sure of finding an organization chart and, perhaps, a manual defining the responsibilities and reporting relationships within the Engineering Division.

Quite generally the above mentioned weaknesses are not recognized because engineering tasks are getting done and the ill-defined organizational relationships do not appear to be engendering friction.

What is overlooked is the fact that although the engineering tasks are being met in a harmonious manner, they are infrequently completed on the schedule anticipated, and seldom within the manpower or cost estimated. Organizational deficiencies are being offset by the addition of increased numbers of engineers, by the particular talents of key people, and by special or added individual effort in sharing responsibilities and "bending over backwards" to avoid friction.

The insufficient number of engineers with interest in, and a keen mind for, organization and management imposes a significant restriction on corporate growth. Most engineers, by their nature, are inclined to resist organization, administrative procedure and cost consciousness, and few have been trained to it. Happily, leading engineering schools have come to recognize the increasing significance of producing graduates with a knowledge of scientific management as well as a technical training specialty. Subjects pertaining to engineering organization and administration are gaining ever-widening recognition as necessary elements in the engineering school curriculums.

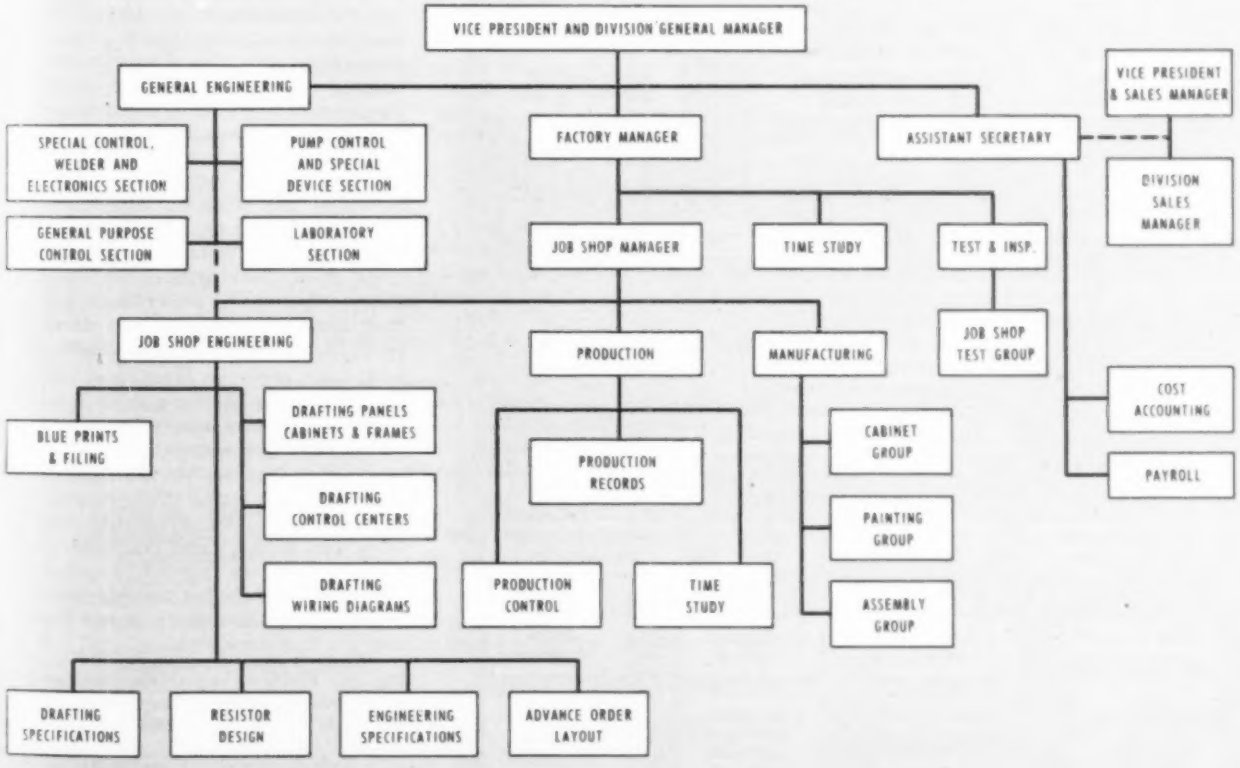
*Organizational Planning.* This is one of the tasks to which an engineering executive must be constantly alert if he is to do anything more than let organization form around people and along the lines of least resistance. The latter procedure presupposes that the right type of people are on hand to achieve the objective for which the organization exists; but without a plan of organization, there is no basis for determining personnel requirements. Furthermore, people are temporary, whereas the objective of an organization has a degree of permanence.

By the foregoing statements it is not suggested that effective organization planning can be accomplished without reference to existing or available personnel. On the contrary, such an approach would result in the waste of the abilities of some engineers and the assignment to others of duties for which they are not qualified.

To proceed in organization planning in a manner both sound and realistic, the engineering executive need only recognize the necessity of having a properly thought out plan of organization, adhering to accepted principles and based on the objectives that his organization is to achieve. Then he can modify that organization to meet the really important personnel factors which should be reflected in it. The so-called ideal plan may never be achieved, since there are always modifying factors, usually related to personnel. Nevertheless, there are advantages in having at all times a well-worked out pattern of organization toward which to strive.

If this pattern does not exist, the decisions made from time to time may be inconsistent and not against the background of an objective solution. For instance, a modification made in an organization setup to reflect the peculiarities of a given individual should be adjusted when that individual passes from the picture. An ideal or objective organiza-

**Fig. 11—Job shop organization has the engineering functions split between General Engineering responsible to the General Manager, and Job Shop Engineering under the Job Shop Manager, but functionally responsible to Chief Engineer.**



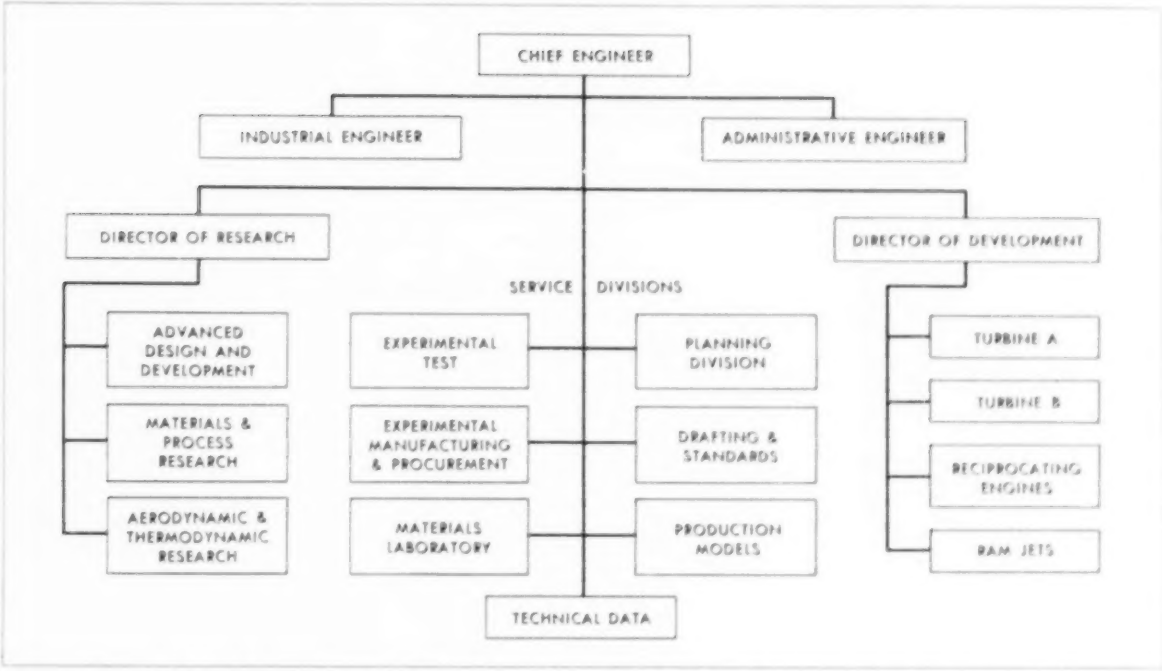
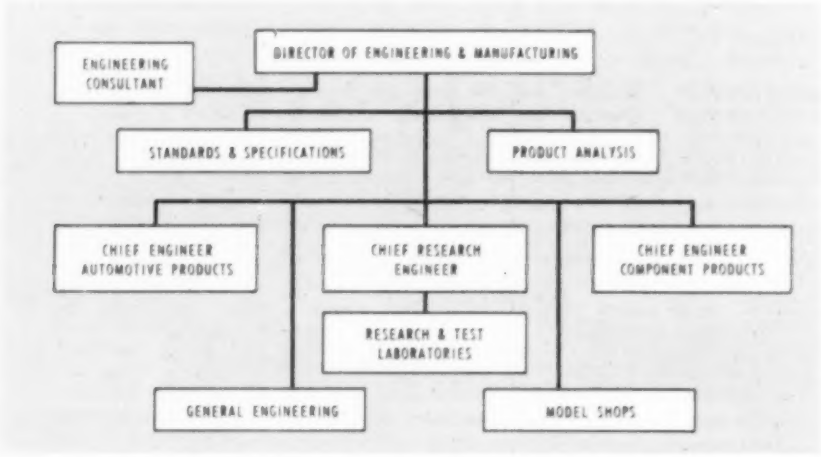



**Fig. 12 – Organization by technical function is becoming more prevalent at the top level of engineering departments. This practice is largely the result of a marked trend toward technical specialization in most industrial fields.**



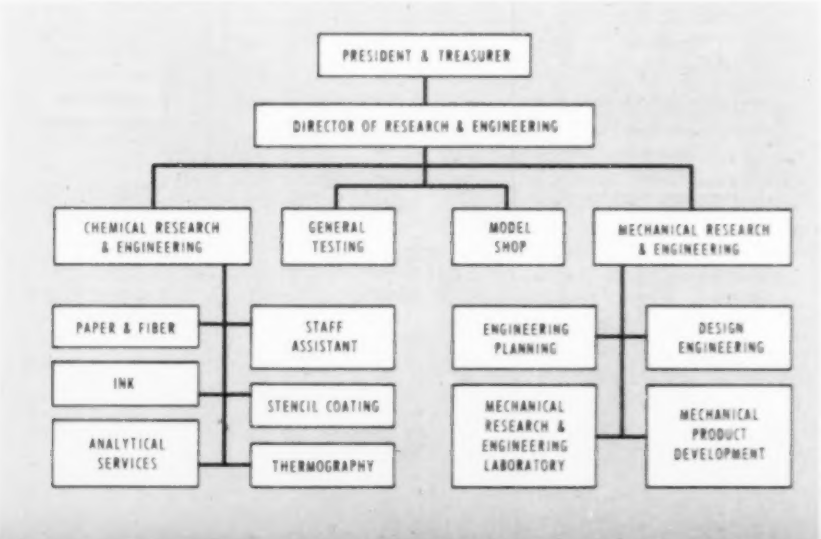




**Fig. 13 – Both the functional and product types of organization are found in single-division, multi-product firms.**

agement to capitalize consistently on these opportunities to reach closer to the perfect plan of organization.

*Basic Principles.* It may be well for the engineering executive to consider the basic principles of organization listed in Table III. Particular attention should be given the principles numbered 3 through 9, since they are often violated as a group.

Where responsibilities and relationships are unclear, appreciable time and expense must be devoted to coordination to avoid or minimize duplication, overlapping or conflict of effort. Engineering supervisors will find themselves spending a large proportion of their time coordinating with each other on matters of unspecified responsibility and, in committee action, on subjects that should be resolved in a straightforward organizational manner on the basis of individual rather than group responsibility. As a consequence, they may have insufficient time available to study objectives, formulate policy and develop plans for the engineering function, although these are key

**Fig. 14 – Fields of engineering, such as mechanical and chemical are sometimes the basis for dividing responsibilities.**

responsibilities of a Director of Research or Engineering.

Lack of clarity as regards responsibilities and reporting relationships results in less effective utilization of engineering manpower. This is a particularly serious thing for companies that are called upon to take on defense production, since it handicaps their expansion of current operations. Similarly, by hindering orderly contraction, this lack of clarity will be an obstacle in the transition to profitable peacetime operations.

Although authority to act should be delegated and exercised at the lowest practical level, in many engineering organizations technical details reach the most senior executives because subordinates at successive levels below them are inclined to believe that each participant will add something of value. Yet, this approach ignores the fact that slight additional refinement of plan, analysis or design thus obtained may not justify the drain on a top-engineering executive's time. In addition, this practice hampers the development of responsibility and judgment in subordinates.

*Forms of Organization.* Engineering activity, like that of manufacturing or sales, can be organized by product or by function. And, just as sales activity is divided according to geographic territory, engineering can be classified by specific fields of engineering knowledge, such as electrical and mechanical.

A company's basic form of engineering organization is that which governs the division of engineering responsibility at the first (highest) organizational level. This may be the level immediately below the senior engineering executive, or the level below the chief executive of the company, as is the case when research is organized apart from other engineering effort.

The nature of a company's product, the size of the company and its objectives and policies will largely determine the basic form of its engineering organization. However, because of the marked trend to technical specialization in all fields and the importance that functionalization has assumed in modern business, the most prevalent form at the top level of engineering organization is the functional form. This is exemplified in Fig. 12. The major breakdown below the Chief Engineer organizes research under a Director of Research; product design and development under a Director of Development; and the various services, by function, under divisions reporting to the Chief Engineer. In addition, administrative functions are grouped, under an Industrial Engineer and an Administrative Engineer. At the second level on this same chart, the responsibilities of the Director of Development are organized by product, whereas the research divisions are an example of secondary organization by function.

Probably the most popular form of engineering top organization for single division, multi-product operations is that including both the functional and product types of responsibility groupings. This pattern of basic organization is illustrated by Fig. 13. Companies using this scheme generally organize by function those elements of their engineering activity that can most economically and effectively be handled on a centralized basis. This usually means that, in addition to administration, the research function and sometimes testing, is grouped for all products whereas product design engineering is organized first by product, and then, perhaps secondarily, by function. All service and customer liaison engineering can be on an integrated basis when the products are appropriately related from a technical standpoint, but would otherwise warrant being assigned organizationally by product.

Similar to this scheme of engineering basic organization is the type that includes functional groupings and groupings by field of engineering. The products of the A. B. Dick Company, though related, are nonetheless diverse in industry character — mechanical, chemical and paper converting. For this reason, as their organization shows in Fig. 14, the fundamental breakdown below the Director of Research Engineering is one that separates chemical from mechanical engineering. There are, in addition, two functional units, one directed to General Testing and the other to Model Shop work. The centralization of testing for both chemical and mechanical products gives it an objective character that would be difficult to attain with testing under the jurisdiction of the person responsible for the development itself.

The second level in this organization illustrates the fact that mechanical research and engineering responsibility is generally delegated by function, whereas chemical research and engineering, by its nature, is more often best organized by material or product elements.

Engineering's basic organization in a large motor car company, Fig. 15, includes examples of all three types of organizational approach, namely, by function, by product and by field of engineering. Fundamentally, it is an organization by function—personnel, administration, styling, testing, research and design. However, the design engineering function itself has been organized by type of product, so as to be represented by two separate Passenger Car Engineering Departments and one Commercial Vehicle Engineering Department. Although not shown on this chart, each of the Passenger Car Departments consists of two sections organized by product component (Chassis and Engine) and a Body Engineer, plus an Experimental Section and a Scheduling and Records Section. The Commercial Vehicle Engineering Department consists of four sections

**Table III — Basic Principles of Organization**

1. Organization should have a clearly understood objective.
2. Every function essential to the objective should be represented in the organization.
3. Responsibilities of all members of the organization should be clearly defined.
4. Authority should be clearly defined.
5. Responsibility should be matched with commensurate authority.
6. Each person should know to whom he reports and who reports to him.
7. No person should report to more than one supervisor.
8. Authority to act should be delegated to the lowest practical organizational level.
9. Top management should be free of burdensome detail.
10. Duplicating, overlapping and conflicting functions should be eliminated.
11. An excessive number of persons should not report directly to any one supervisor.
12. Related functions should be grouped; unrelated functions separated.
13. Over-elaborate organization should be avoided.
14. Consistent patterns of organization should be used at all levels, to the maximum extent practicable.

organized by product (Truck, Coach, Tractor and Engine) and a Body Engineer, plus a Resident Engineer and a Scheduling and Records Section.

The Electrical Engineering Department, Fig. 15, is a design department encompassing design responsibilities within the field of electrical engineering for all products. Thus, it represents a service organization to the other design departments, having within itself sections by product systems – ignition, instrument and controls, heating and ventilating, starting, lighting and accessory. A Production Contact Engineering Section is also included, in addition to a Records Section.

The Body Engineering Department represents a particularly interesting addition to the other product engineering departments, in that it serves as a common, consolidated activity. Included in its own organization is a Structural Development Section, with a testing laboratory, styling layout sections and a large number of design units, each representing one part of the product body. Centralizing of body engineering to make its basic responsibility segregation by component parts rather than by finished vehicle type, can bring about product improvement and cost reduction. This also makes possible the high degree of interchangeability that the manufacturer desires. The Body Engineer indicated above as being in each of the Passenger Car Engineering Departments and the Commercial Vehicle Engineering Department provides the liaison essential under an arrangement of this kind.

*Research Organization.* In a small company, a satisfactory research unit may consist of one Research Engineer and an assistant, plus a laboratory technician. In a larger company, the research organization is generally larger in proportion to the greater capital investment or greater plant capacity, and may include hundreds of Research Engineers and technicians. Some moderate-size companies rely mainly on a research consultant or consulting company to work in collaboration with a few top engineers of the company.

Generally, research is centralized as a single organizational unit. However, multi-plant companies with widely varying product lines and widely separated plants have found it best to have a research unit at each product manufacturing plant.

When research is centralized for all parts and products of a company, the organizational form may be oriented by projects, product, function, processes, fields of science, or specialization of skill (research techniques), as the particular circumstances may warrant. As research organizations increase in size, specialization and segregation of specific forms of work under specially equipped groups becomes necessary. This is well illustrated by the Gulf Oil Corporation's wholly-owned subsidiary, the Gulf Research & Development Company, whose own internal organization, Fig. 16, depends upon the nature of the activities it has to perform in serving as a centralized research department for all affiliated companies of the parent organization. The latter is a fully integrated oil company, in that it engages in all operations associated with the discovery, production, transportation and refining of crude petroleum as well as the sale of refined petroleum products to industrial, wholesale and retail markets. Its research program includes problems arising from all of these varied activities, and its organization for research and development reflects this, as is shown by the chart on opposite page.

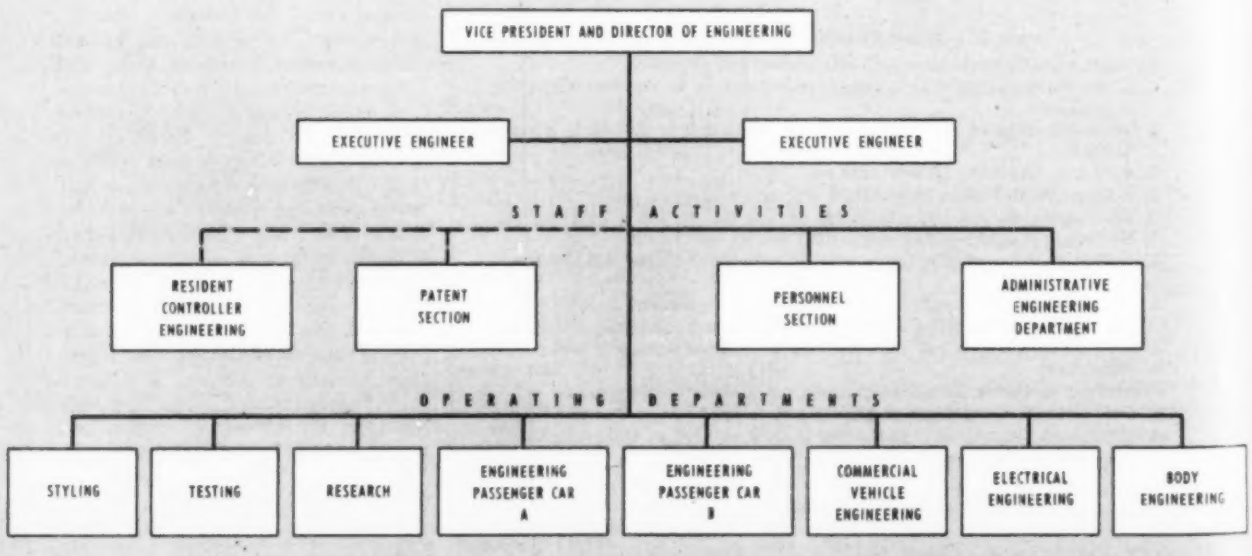
Even in corporations far smaller than the aforementioned, there is a growing tendency to separate research from the other functions of the business, so as to make the research head responsible to top management and the function divorced from the particular influence of either the sales, manufacturing or engineering departments.

*Product Design Organization.* Under normal circumstances, this part of the engineering organization is responsible for:

(a) Product design and the preparation of engineering data, drawings, and models, including part numbers and names, parts lists and detailed drawings of parts.

(b) Analysis of the manufacturing process and determination of the type of equipment to be used. Prime responsibility for process control and exact spe-

**Fig.15 – All three types of organization – function, product and engineering field – are represented in the basic engineering structure of a large motor car company. Passenger Car Departments are organized by product components.**



cifications should normally fall upon engineering, with collaboration from production and cost functions.

(c) Control over product simplification and the setting of industrial standards. This involves control of product, engineering design, material and process (operating methods and work performance).

There is, of course, no one "ideal" definition for product design engineering organization with respect to drawing the line between it and manufacturing. For example, the location of a Standards and Methods Department and a Tool Engineering function may be governed by the size of the company and the relative importance of these functions with respect to the product.

As shown in Figs. 12 and 13, product design responsibility is usually organized by project or product unit, and serviced by central units covering such elements as model shop, experimental test and styling. Draftsmen are permanently assigned to the product design units to the extent that there is a more or less continuing design workload, or a special design talent required. However, when projects and their design personnel requirements are variable, it is better practice to gain flexibility by carrying the design engineers and draftsmen in a general engineering unit from which they can be assigned to specific design projects as required.

Product decisions are best when based on models that have been completely and thoroughly worked out to the last detail, and when close liaison with manufacturing has made certain that the proposed design is satisfactory from a production and cost standpoint.

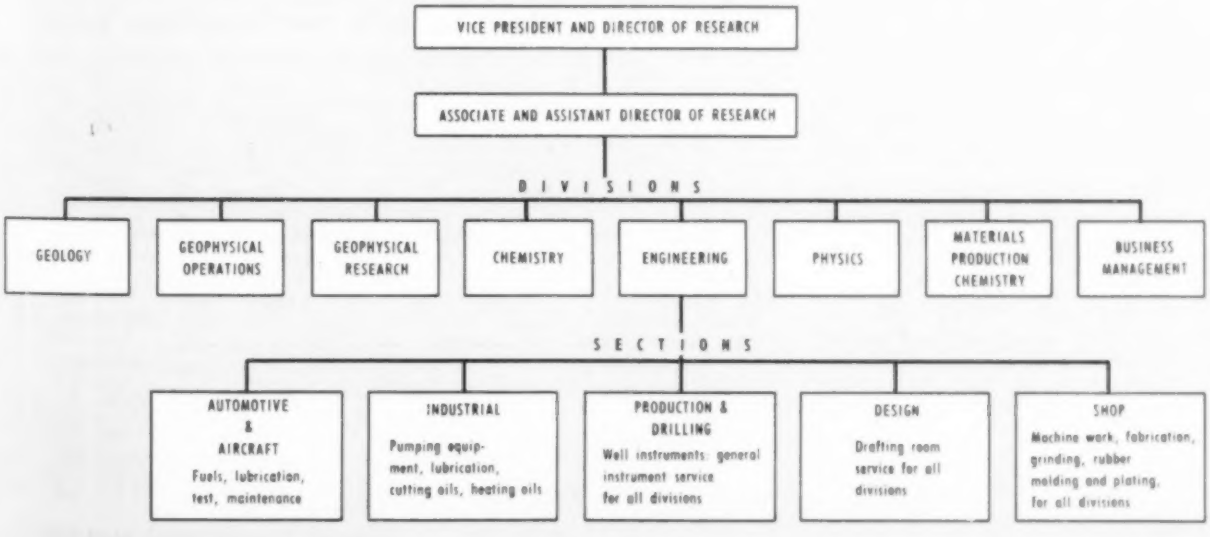
Styling, or industrial design, needs no argument in its favor, so significant has it become in product development. It is common practice for companies to supplement the talents of their own design engineers with the advice and assistance of recognized specialists in preparing a long-range styling program and in developing current design styling from the standpoint of color, form and packaging.

*Service Engineering Organization.* There are wide variations in organization for engineering technical liaison and field service, governed mainly by the nature of the product, method of marketing and company policy. In most cases, service is closely related to sales, if not an organizational adjunct thereof. The engineering organization shown in Fig. 14 includes no customer technical service function because it is within the jurisdiction of sales engineering and sales service departments under the Vice President-Sales. Liaison with the field is through sales engineering. Minor test facilities are maintained for the purpose of working out ways for specific customers to use a product to do something for which it may not have been designed. This sort of applications engineering has become necessary because even the newest model finds some customers who want to utilize it in a non-standard manner. Needless to say, this customer service sometimes leads to the company becoming convinced of a need for product modification.

A company making several special lines of nuts, screws and washers includes in its service engineering organization a drafting section, small model shop, and a group of the field engineers who do applications work in liaison with the Sales Department. A principal responsibility of this group is to identify and report on opportunities to meet customer needs through action that might be taken product-wise. The same company broke away from a previous practice of using sales engineers for this customer contact work, when these engineers became unduly concerned with account loyalties, price and delivery problems, and carrying mail for the Sales Department.

Where the product line involves highly technical design, installation and maintenance problems, the service engineering function should be placed in the Engineering Division, and liaison maintained with the sales function. Aircraft and aircraft accessory companies have product lines of this nature, as do most of the large industrial apparatus manufacturers. As a result, their service engineering activities generally include provision of technical manuals, field service and service bulletins, customer training and various special projects. A typical organization under a Chief Service Engineer in the aircraft in-

**Fig. 16 – Research activities can be organized in many different forms. The Gulf Research and Development Company is set up on a divisional level according to scientific field and by product and function at the sectional level.**



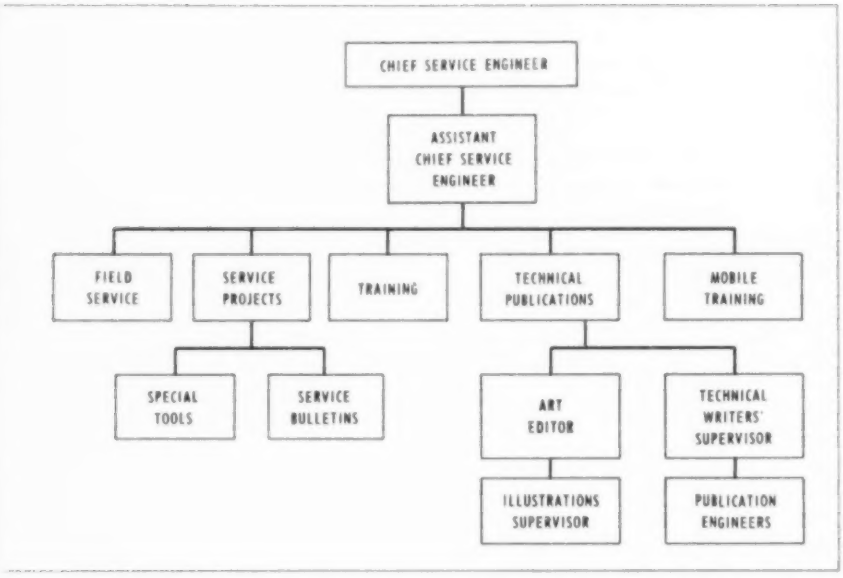



**Fig. 17 – The Service function is organized in the Engineering Division when a product line involves technical design, installation and maintenance problems.**

dustry, Fig. 17, indicates the necessary coverage of the elements mentioned.

*Administrative Engineering Organization.* Without sound engineering administration, the technical advantages of a competent staff and top-grade facilities can be offset through the disadvantages of inaccurate estimating, faulty scheduling, manpower difficulties and high costs. This phase of engineering should be organized at the staff level with the Administrative Engineer reporting to the Chief Engineer and the group as a whole acting as a service department to the other engineering operating activities.

Under normal circumstances, the work of this group includes planning, scheduling, budget and cost functions. Some companies add the administration of engineering personnel to the responsibility of this group, while others, largely those employing several hundred engineers, organize personnel independently of other administrative functions.

Planning and scheduling are key responsibilities of the Administrative Engineer and his group. Duties include keeping track of all engineering activities within the company, and making sure that all projects are authorized, scheduled, and coordinated within engineering so that design and release commitments can be met. Planning should also insure that engineering top management receives periodic progress reports by which to control all projects; and that engineering releases, changes, prints and parts lists are processed, recorded and distributed.

In many companies, engineering planning evaluates and coordinates all matters concerned with the materials needed for design projects, prepares all orders needed to meet the material requirements of production schedules, and acts as liaison between engineering, material and production planning. Some organizations even include responsibility for procuring the materials used in experimental pilot models.

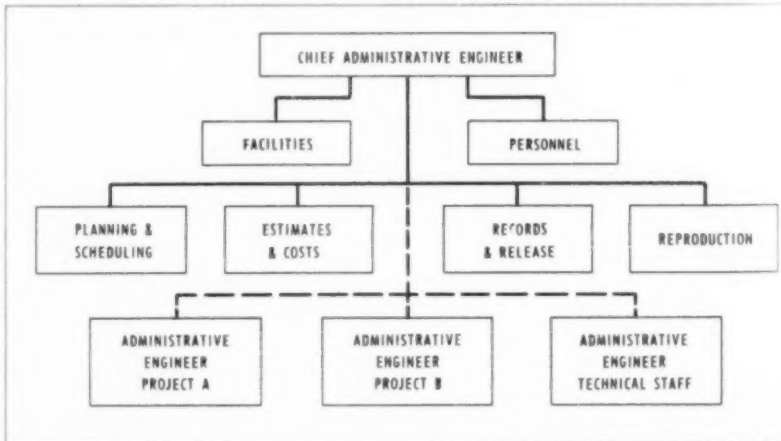
Engineering cost estimation, budgets and budgetary control are other vital functions of the Administrative Engineer. He should work closely with the technical staff and project engineers in the event he is called upon to supply cost estimates for proposed designs. He should have close liaison with the production engineers for the purpose of determining the best methods for producing new designs. And, he should be in constant touch with the cost estimating and accounting functions of the finance division, analyzing cost information and transmitting it to staff engineers for use when considering new design projects.

In addition, to the primary duties outlined above, the Administrative Engineer should be responsible for coordinating certain activities. Typical of these are the processing of engineering travel paperwork, overtime authorizations and purchase requisitions, and the scheduling of special engineering facilities.

In large engineering organizations, a separate administrative unit is sometimes assigned to each of the major projects, working as a part of the organization under the Project Engineer, but functionally responsible to a Chief Administrative Engineer. Fig. 18 shows an organization of this character.

*Multi-Product, Multi-Divisional Organization.* A large company with several different product divisions at various locations should have its engineering activities so organized as to permit interdivisional projects or product problems being handled satisfactorily. Generally, each division requires its own product engineering department, and there is a natural tendency for these departments to become almost wholly engrossed in immediate and early-return projects at the expense of long-range developmental programs that require considerable attention. To offset this

**Fig. 18 – An Administrative Engineer is sometimes assigned to each major project although he is functionally responsible to Chief Administrative Engineer.**



tendency and to coordinate engineering on a company-wide basis, a central engineering staff can be formed under an engineering executive at the top-management level. This executive, preferably a vice-president of the company, should be responsible for the development of basic engineering policies, plans and procedures and for the technical excellence of the engineering function throughout the company. He should have line authority over only the activities that are part of his headquarters organization. These might be limited or extensive in number and size, depending largely on the nature and diversity of the product lines. Research and test may or may not be centralized under top management direction.

The engineering relationships shown in Fig. 19 are for a company whose product lines are sufficiently diverse to justify decentralization of research and test to several different laboratory facilities located near and allied with the respective product division organizations. Hence, the headquarters staff organization is relatively small. A general patent attorney manages the Patent Department, which keeps the company out of trouble patent-wise and gives patent research and other services to manufacturing as well as engineering activities. An Industrial Engineering Department concerns itself with giving staff assistance to the product engineering departments of the several operating divisions. In addition, it does some design work from the standpoint of styling, employing design and color consultants to assist in this service to all product divisions. The Materials Engineering and Parts Standards Department is responsible for the development of standardization practices as they pertain to parts and materials on a company-wide basis. It provides the necessary close liaison with the purchasing and materials control function centralized at the company headquarters level, and serves as the focal point of product committee activity coordinated by the Director of Engineering.

*Liaison Relationships.* Effective working relationships, generally referred to as liaison, are vitally important to engineering management. On the one hand, there must be close working relationships between elements within the engineering organization itself; on the other, close and smooth working relationships are necessary between certain elements of the engineering function and others in the sales, manufacturing, purchasing and finance functions of the business.

The larger and more complex and widely separated the organization, the more difficult achievement of the desired internal relationships becomes. How are the problems met and lessons learned in one part of the organization to reach interested persons in other parts? How are uniformity and consistency in intradepartmental operating relationships achieved? These matters must not be left to personnel rotation or the chance of individual action.

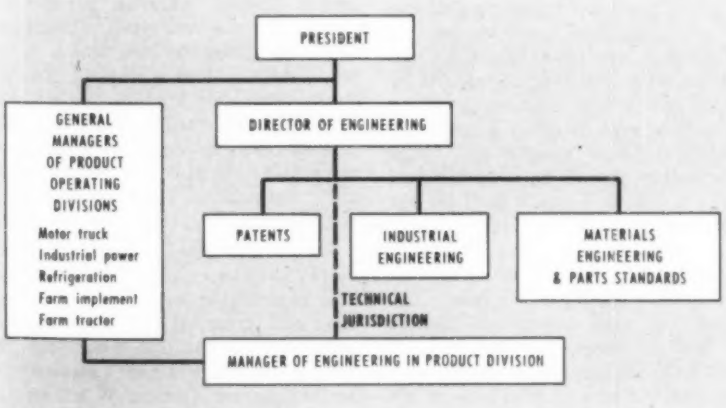
For the smaller engineering departments, periodic staff meetings may solve the problem. For some of the larger ones, staff meetings may also be effective, provided the physical separation is not great and a system of subordinate staff meetings carries information to the lower echelons of engineering supervision. This approach should be backed by written operating instructions.

In the case of relatively large and multiplant organizations, interchange of technical knowledge of common concern can be established on a uniform basis through written instructions. Also, where there are central engineering units or functional staff units at the company headquarters level, these should have the responsibility of serving as clearing houses for the desired interchange of technical information. The assignment of an individual engineer as liaison from one product division to another, or from one engineering activity to another in the same division, is a special though not uncommon means of maintaining a satisfactory working relationship between engineering activities. It has the disadvantage of being an expensive method and of sometimes creating administrative problems. However, it has the great advantage of being the most direct and potentially effective method. The use of liaison engineers should not be overemphasized, lest it become organizational habit in lieu of establishing clear definition of responsibility relationships and satisfactory work performance. Committee organization within the engineering function is another legitimate means of promoting liaison between its different elements. However, it too should not come to be considered as the remedy for basic organizational or staffing ills.

Operating liaison between engineering activity and functions outside the engineering organization can be provided by assignment of liaison personnel from one department to another, as for example, from engineering to sales, production (tooling) to engineering, or engineering to purchasing. The better solution is to facilitate liaison through obtaining or developing salesmen who have sufficient engineering training to work closely with service engineers or applications engineers; or product engineers with sufficient knowledge of the company's shop equipment to be able to design with its type and capacity in mind. An increasing number of large companies have established the position of Materials Engineer, attached either to the product engineering, purchasing or research organization. He is usually responsible for finding substitute materials to reduce cost or to offset the shortages that are common under a program of government controls.

*Committees* – A clear definition of the functions, responsibilities and

**Fig. 19 – When a company's product lines are widely diversified, separate and specialized research facilities are usually located near each product division.**



authority of committees is an essential for sound organization and this policy is generally adhered to in companies that consider committees the most satisfactory means of bringing about adequate liaison between engineering and other functions at operating levels.

The propriety of a committee's existence should be determined by the function it performs. It should not be assigned an administrative, supervisory or executive role because it cannot supplant an executive position. But a committee can properly fulfill the purpose of settling issues or making decisions, where problems can best be resolved by those who represent several functions and, therefore, several points of view. It can also serve effectively in an advisory role, particularly in matters concerning policy. The larger the organization, the more committee effort required in meeting the need for a coordinating force binding all elements together. Engineering management has, in its own interests, an obligation to company management with respect to effective committee organization and maximum utility through efficient operation.

# Engineering Staffing

Much is being said on the subject of engineering staffing in view of the increasingly critical shortage of engineering personnel and the stiff competition experienced in recruiting and holding talented engineers. Techniques for recruiting and selecting engineers, aptitude testing, supervisory training and performance rating are receiving more attention than even before. Many companies have even established elaborate systems and policies (Table II) to insure proper handling of all engineering personnel problems.

*Recruitment and Selection.* Companies having a periodic need for graduate engineers work closely with engineering schools, and company representatives visit campuses at regular intervals in teams of two or more. In many cases, at least one member of the team is an engineer.

In addition to seeking permanent employees from among the graduating classes, some companies recruit undergraduates for work as apprentices during the summer vacation period. Other concerns augment their staffs in the same period by employing engineering school faculty members.

Manpower shortages and industrial competition for engineering graduates largely determines the degree of choice a company has in the selection of engineers from candidates recruited. It is wise to prepare for that choice not only through interview appraisals, but also by using scientific techniques of testing for aptitude and personality traits.

*Indoctrination.* Regardless of a company's size, there should be a planned program of indoctrination for new engineers. The program should first acquaint them with the company's historical background, its current production and products under development, its plant and facilities and its general organization. Secondly, it should explain the organization of the engineering function, listing the names of key personnel, and outline the engineering objectives, policies, and procedures. The latter naturally include standard practices with respect to drawing and part numbering, drafting procedure and release routines. Finally, each new man should be acquainted with the company's common rules or customs. These include identification, absence, plant hospital, cafeteria, pay day, suggestion plan, credit union, retirement, savings bonds, insurance plans, holidays, bulletin boards, vacation and parking.

Whether the company is small and requires only a day or two to complete this indoctrination, or large and needs several weeks to do the job properly, there should be a program and it should be standard procedure. Such a practice insures rapid orientation of the new engineer in his every-day routine.

*Assignment.* Research, product design and service engineering call for different types of engineering talent; and administrative functions require yet another leaning or talent. To determine where an engineer should be placed in the organization, previous experience and, possibly a test, will indicate a man's "longest suit". This information should be recorded and kept current as a guide both for his own assignments and for use by other staff members when they need the benefit of his experience. The practice of keeping a composite inventory of staff experience should not lead to unnecessary specialization. It should mean, however, that a new man put on a certain type of job might be advised by his supervisor, "For any technical questions concerning this project, consult Mr. . . ."

*Training and Executive Development.* A conscious effort to train engineering personnel should not end with the indoctrination course. Training should continue as an underlying theme to be followed through job rotation, conferences and lectures, technical notices and memoranda, off-the-job courses and other means, as well as through on-the-job experience.

Secondly, training should include concerted effort to acquaint engineers with other phases of the business, particularly those elements of sales, manufacturing and finance that impinge directly on engineering activity. This broadening of the engineer's viewpoint has many benefits and becomes important in qualifying some for supervisory and, ultimately, executive responsibilities.

Specialization by function and within function has made it increasingly difficult for industry to develop executives with administrative capacity and interest, as well as an understanding of the technical functions of the business. For this reason, many companies are engaging qualified consultants to tailor a plan to the particular needs of the organization.

The engineering staff should be called upon to provide a greater number than heretofore, of general management executives, in addition to filling top engineering jobs with competent administrators. To do this, it is first necessary to recognize the difference between those engineers who have a present or potential executive talent and those who have primarily a present or latent design talent or technical genius. Neither type should be considered as being handicapped, and management should give them equal rank in all respects throughout their careers.

This personnel policy suggests different, though parallel, promotion ladders for the two types, a decision as to the category into which each engineer fits, and a chief-engineer status attainable for both types. The line of action should not be difficult to spot because past experience has made clear the aptitude and personality distinctions between the true engineer type and the executive type.

As for the chief-engineer status, there might be a chief technical engineer responsible for guiding the creative and technical efforts of the department and, at the same time, a chief executive engineer responsible for the administration of all engineering activities not strictly of a technical nature.

Boeing Airplane Company

**Fig. 20 — In the recruitment and training of new engineers, interviews and periodic consultations should be conducted by technically trained personnel.**

Republic Aviation Corporation

**Fig. 21 — Detail work requires adequate lighting and attention to desk spacing.**

# Working Conditions and Facilities

There is little reason for establishing a fine engineering and research organization, if serious attention is not given to the physical environment in which the engineers work.

*Space and Layout.* When drafting rooms, laboratories or offices are under consideration, space requirements should be calculated from accepted standard allowances and the possibility of future expansion taken into account. This is particularly true today when a continued advance of engineering knowledge is contributing to a marked growth in engineering activity, even in relatively small companies. Also, it should be remembered that under pressure of competition, most companies set growth as an objective.

Layout of engineering space is also important. The various activities within the organization should be positioned with respect to their own activity and their operating interrelationships. Distances and accessibility should be studied in developing the layout.

*Illumination.* Proper lighting can help to offset the effects of insufficient space and poor layout. Experiments and experience have shown that drawing spoilage is decreased and quality improved by adequate lighting. The same holds true with respect to production of engineering work, and yet many companies overlook the benefits of taking as orderly and scientific an approach to lighting as they do to design problems.

The qualities of good light are adequate intensity, proper diffusion and an absence of glare. Generally, from 50 to 100 foot-candles are needed at the working surface in engineering offices and drafting rooms. In laboratories, the same intensity, and sometimes more, is needed. Proper diffusion calls for the absence of shadows or strong contrasts. Glare can be caused by too great intensity, too sharp contrast, improper location of light source and, most frequently, by improper diffusion.

Windows and the paint on interior surfaces, including equipment, have a definite influence on internal lighting conditions. It is generally preferable to have colors that reflect rather than absorb light, but which are tinted to reduce glare. A slight yellow tint in drawing paper reduces glare and improves engineering drafting performance through reduction of excessive fatigue. The U. S. Navy, several schools and some government bureaus have measured marked reductions in work errors following a decrease of lighting-contrast ratio, mainly by supplying desks with grey linoleum tops and tinted memo forms.

Laboratory lighting poses a number of special problems depending on the color of equipment, location and number of windows, type of work being done, and background, including any special clothing worn by laboratory workers. Critical research laboratory work should take into account the glare and contrast factors, as has been done in the operating rooms of hospitals to minimize strain and fatigue. A satisfactory condition is obtained when the reflection relationships between wall, furniture, floor, ceiling and equipment are such that the eye is not called upon to readjust itself constantly as it scans the different sections of the laboratory.

This balance is sometimes hard to attain without expert advice. Thus some companies turn to color and illumination consultants for analysis and recommendations.

*Ventilation and Air Conditioning.* Satisfactory air conditions are not only conducive to efficient work, but also have an effect on the behavior of the equipment and some of the materials with which an engineer works.

Air conditions depend on humidity, temperature and movement of air, and these factors must be considered in relation to each other. The most satisfactory facilities are those regulated by an automatically controlled blower or air conditioning system.

*Technical Facilities.* Research and testing laboratories should be in keeping with the company's size, character, engineering objectives and policies, and research program. Similarly, model or sample shop facilities commensurate with operational requirements should be provided.

Every engineering department should have its own copying and reproduction equipment. Selection of the proper type is important and consideration should always be given to the effect of the reproduction method on the original drawing. The type that is "easiest" on the originals by depreciating them least should be favored.

*Library.* An engineering depart-

ment library is another necessary adjunct and a further means of equipping the organization to derive maximum benefit from the engineers' time. In a small company, the library may be nothing more than a well-considered selection of reference books and a file of related engineering periodicals or trade journals. Larger organizations should establish a library for which there are definite procedures for maintenance and use, as carried out by an office secretary or clerk. The largest engineering activities customarily have a library maintained under the full-time attention of a qualified librarian who provides library reference service to those desiring it, regardless of the department involved.

# Systems and Control Procedures

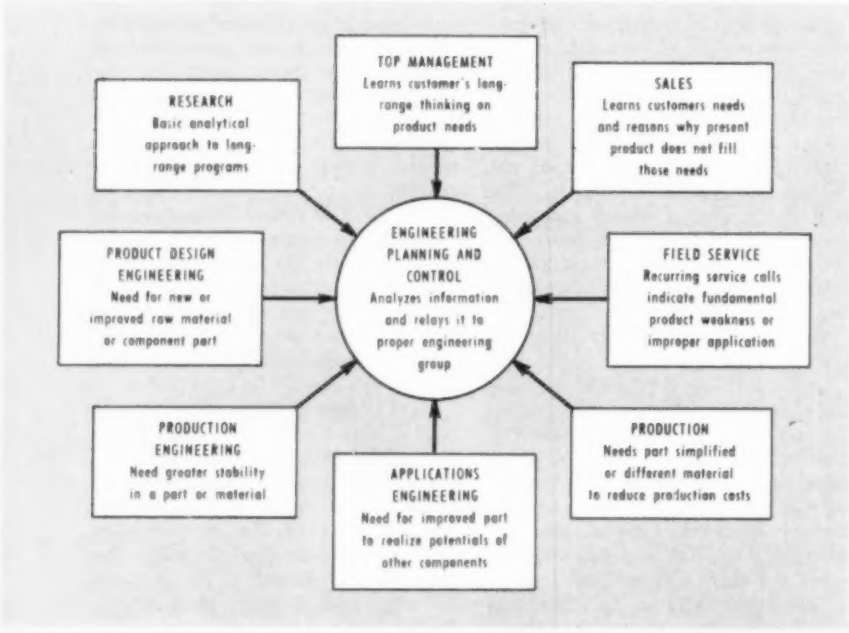
Systems and control procedures for the authorization, planning and execution of engineering activity are the last of the essentials of engineering management. To be adequate, systems must prescribe planning and operating procedures at all levels, together with records and reports in support of control procedures by which management can check whether the systems are followed and whether assigned tasks are performed satisfactorily.

### *Research Projects*

*Authorization.* The establishment of research projects, regardless of their origin, Fig. 22, should be governed by a suitable authorization procedure. Responsibility for authorization of research should rest with a committee representing the major functions of the company, or with the chief executive, advised by such a committee. This group might consist of the President, Director of Engineering and Research, Works Manager, Director of Sales, and Manager of Sales Engineering. In a number of companies, it is the Board of Directors or Executive Committee. However, it may be advantageous to allow the Director of Engineering and Research to do some research on his own authority, subject only to budget limitations.

In companies where the Research Director ranks as a major executive, responsibility for all project authorizations can logically be placed with him, especially if a budget limitation has been set by the President or Board of Directors. Large multi-plant (product division) companies with a centralized research organization almost invariably rely on committee action to determine and authorize various research projects.

**Fig. 22 – Engineering assignments, either research or product design, can originate in any phase of a company, such as top management, sales or production.**


TOP MANAGEMENT
Learns customer's long-range thinking on product needs
RESEARCH
Basic analytical approach to long-range programs
SALES
Learns customers needs and reasons why present product does not fill those needs
PRODUCT DESIGN ENGINEERING
Need for new or improved raw material or component part
ENGINEERING PLANNING AND CONTROL
Analyzes information and relays it to proper engineering group
FIELD SERVICE
Recurring service calls indicate fundamental product weakness or improper application
PRODUCTION ENGINEERING
Need greater stability in a part or material
APPLICATIONS ENGINEERING
Need for improved part to realize potentials of other components
PRODUCTION
Needs part simplified or different material to reduce production costs

Authorization, whether by individual or committee, should be based on a well-defined project objective, an estimate with respect to time and cost, and a statement or estimate with respect to the advantages or results anticipated. This implies that some basic planning must be done before the project is authorized. A simple form sheet can be developed and used for this purpose.

*Planning.* Techniques that have proven valuable in the planning of other functions of industry can be of equal value in the management of research engineering.

The first element of research planning is the determination of what is to be done and how, by when, and at what estimated cost. The "when" is approximated by project analysis aimed at identifying the steps involved and a man-hours or man-days estimate for each project. These time estimates are then scheduled against the staff-time available on a calendar basis.

The cost estimate should, when possible, be developed by careful estimation of all labor and material costs and the application of overhead thereto. Included should be estimates of anticipated expenditures for construction, manufacture of tools and castings, commercial testing, or advisory services in connection with the project.

*Work Procedures.* Standardization of research procedures results in minimum confusion and a reduction in the amount of detail work in the conduct of research effort. The standardization should apply to technical procedures, especially laboratory and testing work, as well as to "paperwork" procedures which are so valuable for maintaining coordination between various units within a research division. Other procedures that can be standardized profitably are those governing the sequence of work on various projects, and those related to the preparation and filing of project work papers and reports.

*Control.* A budget is the best means of controlling research activities, if it is not restrictive to the point of precluding or "killing" much-needed research and development. Flexibility is therefore essential.

A research budget fixes a limit of total expense for the period ahead, and acts to keep expenditures under control unless an increase is justified and approved. A good budgetary system promotes long-range planning, thereby increasing the benefits research can give. Not only that, it puts the research function on a sound and

specific financial basis, and imparts a stability to the whole research operation.

The budget for a small research organization is most readily developed by fields of work, subdivided by projects. For a large activity, budget responsibility should be divided first by organizational responsibility and then by products or fields of research, or possibly projects.

Control should be exercised by review of actual research progress against scheduled performance and of actual research expenditures against budgeted expenditures. However, in many cases, actual progress is impossible to measure and the time expended is no criterion. Under these circumstances, the research engineer should report what remains to be done, and estimate the time required to finish the job. This procedure is generally more acceptable to top management for control purposes than the mere record of time and expense already accumulated.

Control of time expended against schedule requires that the manhours expended to date and estimated manhours to completion be recorded in detail. Dollar control against budget necessitates a recording of cost. This can be accumulated in space provided on the authorization form or on a separate project cost report. In either case, labor, materials, overhead and other costs should be recorded and compared with budgeted figures for the period reported and for the project to date.

Normally, the review of progress as based on control reports should be the responsibility of the committee or executive that holds the power of research authorization. Careful thought should be given to the revision of cost estimates and time schedules, and to whether a project should be continued, modified or abandoned. Decisions may be necessary with respect to increasing budget allowances, and shifting project priorities in the light of changes in their relative importance.

### *Design Projects*

A program for the development of design engineering projects is of importance company-wide as well as to engineering management. The system of procedures associated with such a program, as outlined in Table IV for a large automotive accessory manufacturer, should be integrated with the company's overall system of master planning, production scheduling, cost estimating and budgeting control.

**Table IV — Engineering Project Development Program**

**Stage 1. Proposal**
- (a) Provision of proposed specification

**Stage 2. Evaluation**
- (a) Cost estimate (preliminary)
- (b) Translation to preliminary engineering specification
- (c) Patent consideration

**Stage 3. Authorization**
- (a) Approvals
- (b) Assignment to engineering

**Stage 4. Development**
- (a) Study of working principle
- (b) Design layout
- (c) Detailing of piece parts and assemblies in experimental stage
- (d) Cost check
- (e) Standardization
- (f) Product analysis
- (g) Cost estimate
- (h) Patent clearance

**Stage 5. Model Fabrication**
- (a) Standardization (only if started before completion of Stage 4.)
- (b) Product analysis (only if started before completion of Stage 4.)
- (c) Fabrication of piece parts and assembly of model

Preliminary or functional test of model

**Stage 6. Model Testing**
- (a) Specifications for laboratory test
- (b) Test status reports
- (c) Final test report

**Stage 7. Engineering Release**
- (a) "Engineering Release Authority" prepared by engineer
- (b) Approval of release by Sales Department
- (c) Advance material release made to Purchasing and Material Dept.
- (d) Preparation of production drawings and parts lists
- (e) Checking of production drawings and parts lists
- (f) Release of production blueprints and parts lists

If planning and control is sketchy throughout the initial or engineering phases of the complete manufacturing cycle, the following undesirable conditions generally result: (1) Engineering cost will be higher than it should be, with consequent higher total product cost and an adverse effect on pricing and sales volume; (2) inefficiencies in other phases of the manufacturing cycle will be bred from inadequate or inefficient engineering systems and procedures, with consequent effect on schedule and cost; and (3) management's return on its "engineering investment" will be less than it should be because the full potential of engineering talent and facilities is not utilized.

*Authorization.* Design engineering projects can originate from any of the same eight sources shown for research engineering assignments in Fig. 22. Each project should be formulated as a proposed specification that can be incorporated in or with an "Engineering Project Authorization," or some similarly titled form sheet. The latter should provide space for entering cost and time estimates, required evaluations, patent clearances and authorization.

Authority should be granted the engineering executive to approve a design project estimated to cost less than a specified nominal amount. Above that, it is better to place project authorization in the hands of a committee representing sales, engineering and manufacturing. It may also be desirable to have a second cost limit, above which final approval by the president is required.

The sales member of the authorization committee should be charged with indicating in writing the requirements or specifications stemming from sales considerations, and possibly the approximate selling price. The engineering member of the committee should be responsible for translating the project proposal into a preliminary engineering specification and recording engineering time and cost estimates. The manufacturing representative should make recommendations from a production standpoint, so as to guide the design within the manufacturing capabilities of the company or the known capabilities of a subcontractor's facilities. When a patent is involved, the patent section should enter clearance.

Once authorization has been granted by the committee (and president, when necessary), the com-

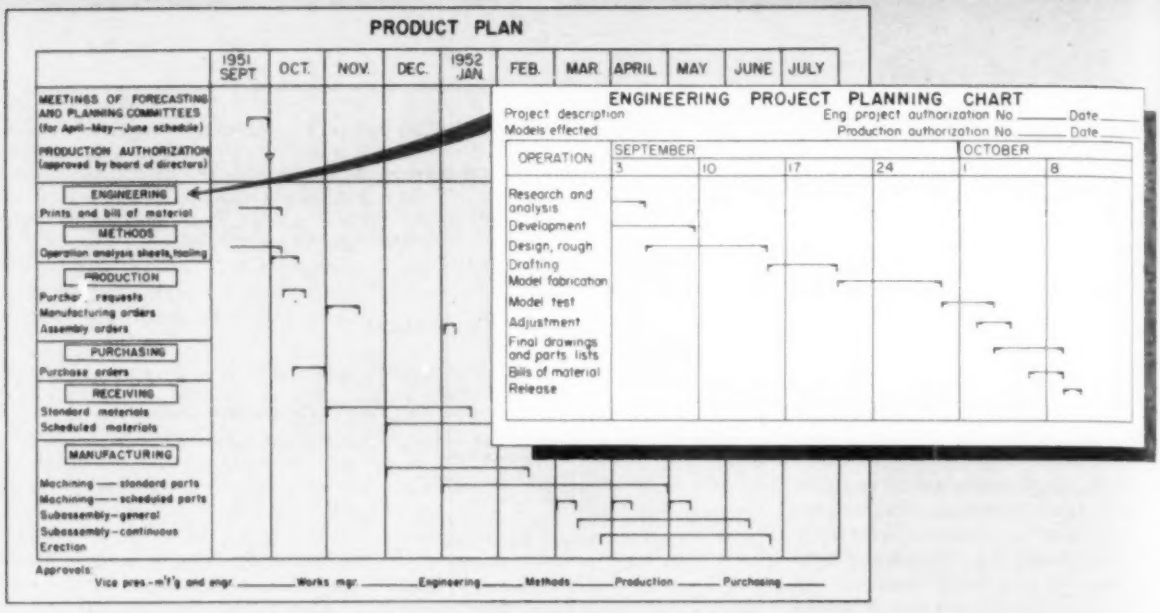



**Fig. 23 – A design project should be planned and scheduled through all phases from authorization to assembly. The engineering scheduling (inset) should precede and be the foundation for company-wide planning and scheduling.**

pleted form can be considered an automatic appropriation for the project. The form should carry a serial number, against which charges can be accumulated for engineering time, materials and other project expenses.

*Planning.* A design project should be planned and scheduled not merely to the completion of the engineering phases, but right on into the framework of a specific product plan based on sales and financial forecasts. This means carrying the engineering planning from design through fabrication and test to production authorization, and the release of drawings and parts lists to production. Engineering should also provide start and finish dates that are in line with the regular production planning and control procedures. A product plan of this type is charted in Fig. 23 and the engineering planning that leads into this plan appears in the inset.

Unless a company's engineering and manufacturing cycle is completed by this close relationship in planning, it becomes vulnerable to having engineering planning that is unrelated to the purchasing forecast, and a design change that obsoletes stock already in inventory.

*Control.* A budget is essential for satisfactory project control because records of project progress should be maintained in terms of dollars as well as by schedule time. As with research, Fig. 24, product design engineers should show progress periodically in terms of percentage completion, so that it can be compared with scheduled progress and costs to date. Developmental projects should be broken down by component elements, and the percentage completion of each component reported periodically as a sign of progress.

### *Engineering Information*

Engineering information can be broken down into standard elements, each of which contributes to the smooth operation of engineering procedure.

*Part Number.* This identifies each individual part, major assembly or sub-assembly, and should be assigned by the designer or Records Department prior to release, in accordance with an established parts numbering system. The part number itself or a letter "E" should indicate when the release is for experimental use only. If the part is subsequently released to production it should be given a regular production number.

*Part Name.* The design engineer should give each individual part or assembly a name prior to release. In naming parts, established or common terminology should be followed wherever possible, and the shortest form consistent with clarity used.

*Model.* Generally, this term is used to identify a class of the product by one or more of the following criteria: General type, capacity or size, general design, plant name or trade name.

*Quantity.* The number of individual parts required per product unit at the particular location on the product covered by the release defines the quantity. When the same part is used at different places on the product, a separate release should be made for each application.

*Material Standard.* This is a written specification of the chemical composition and physical or other properties of a material to be used in the manufacture of a part or product. Every part drawing should bear a reference to the standard that governs the material involved. If there is to be a change in the application of a material standard, it should not be authorized without an Engineering Change Request being approved.

*Process Standard.* Production processes that require engineering laboratory control, as in the chemical and steel industries, should be covered by written specifications. In establishing and controlling process standards, a procedure similar to that used for Material Standards should be followed.

*Performance Standard.* This written specification defines the required performance for an electrical, mechanical or other operating unit, and usually applies to purchased assemblies. The same procedure should be followed here as with the Material and Process Standards.

*Standard Parts.* The Engineering Standards Department should maintain a standard parts book in which parts approved for the company's products are listed by number.

### *Transmittal of Information*

The procedures by which engineering information is conveyed are represented in form sheets.

*Engineering Release (ER).* The re-

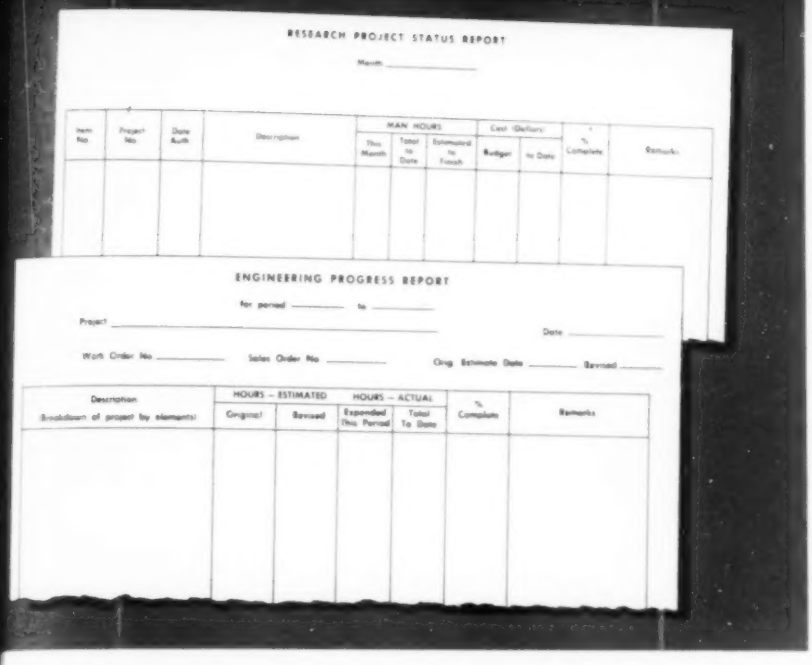



**Fig. 24 – Progress of research and design engineering projects should be reported periodically on special forms in terms of percentage completion.**

lease form identifies with basic information an individual part or assembly and specifies its use for a particular model or several models. All the standard elements of engineering information discussed above should be shown on the form, and no part or assembly considered as officially released for production until the data on this form have been properly disseminated.

*Engineering Change Notice (ECN).* This form describes a change affecting a part or an assembly that has been released for production or experimental use. It is also used to indicate a change in design, or in a Material, Process or Performance Standard.

*Engineering Change Request (ECR or CR).* A standard form is required to obtain engineering approval for changes in design or in the material specification of a part or assembly in production. An *ECR* should become effective when a Change Notice and/or an Engineering Release has been issued, and the required changes made in the design or material specifications.

*Temporary Substitution Authorization (TSA).* This is for regulating and obtaining the necessary engineering approval to make a temporary change in specifications already released to production. A *TSA* should always bear an expiration date.

*Summary Sheet.* Frequently known by other names such as Job Sheet or Work Sheet, the Summary Sheet is used to identify all parts in a group of related parts which are being released or changed at the same time. This sheet does not take the place of Releases or Change Notices; it summarizes a group of them.

*Parts List.* This is a tabulation of all parts required and officially released for a complete standard model of a product or, in some cases, a major assembly. It should indicate the part number, part name, and quantity.

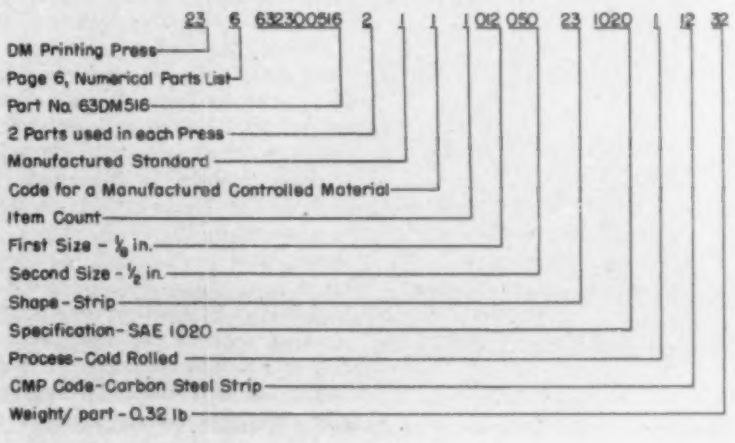
### *Uniform Parts Classification.*

A fully-integrated system of parts classification is an important tool in any mass-production industry. It forms the basis upon which the entire organization depends for dissemination of product information. The essentials of a good system are: (1) Proper indexing of items from the standpoint of functional breakdown of parts and assemblies, (2) simplicity in organization of items under groupings for easy reference and comparison of costs, (3) as few general groupings as necessary for a complete organization, (4) opportunity for expansion of items under general classifications, (5) adequate information to properly identify all parts and assemblies pertaining to the general groupings, and (6) form of organization easily understood.

### *Identifying Controlled Materials*

Compliance with regulations for the Controlled Materials Plan requires the knowledge of how much of each controlled material is used in a finished product. To insure adequate allotments of materials, the engineering department should accurately determine how much by weight, of each controlled material is required. If the product contains a variety of different parts, the engineer will find that a uniform coding system for each part will facilitate making this determination. A tabulating system can then be used, if the coding is properly designed, to produce results with a minimum of clerical work and a high degree of accuracy. An example of a coding system is shown below. Once the gross weight per part is determined, the information is tallied for each class of controlled material. Allowance is then made for cut-off and rejects, and the weight multiplied by the production schedule per quarter to get the material required per quarter.

**Guide to Interpretation of Coded Material on Tabulated Reports**


23 6 632300516 2 1 1 1 012 050 23 1020 1 12 32
DM Printing Press
Page 6, Numerical Parts List
Part No. 63DM516
2 Parts used in each Press
Manufactured Standard
Code for a Manufactured Controlled Material
Item Count
First Size - 1/8 in.
Second Size - 1/2 in.
Shape - Strip
Specification - SAE 1020
Process - Cold Rolled
CMP Code - Carbon Steel Strip
Weight/ part - 0.32 lb

# Correlating the Philosophy a

## What GM Says:

**Based on an interview with T. O. RICHARDS, Head of Laboratory Control, General Motors Research Laboratories Division**

INDUSTRIAL RESEARCH, which has been defined as "trying to find out what you are going to do when you can't keep on doing what you are now" is presently costing American industry 500 million dollars annually. If there was ever any doubt about the value of research it has long been dispelled by the fact that companies, both large and small, have found that these large investments are worthwhile. A recent survey has shown that 70 percent of all research workers are employed in the chemical, petroleum, electrical, machinery, rubber and automotive industries. Thus, the largest and most active research programs are supported by those industries which were themselves created by research.

At General Motors, the Research Laboratories Division represents only a small part of the research and development activity going on within the corporation. General Motors as a whole has 2,200 technicians who are concerned with research, development, and advanced engineering. There are about 150 chemists, 50 physicists, 150 metallurgists, 650 engineers of all classifications, and about 1,250 technical personnel. Of this number, the Research Laboratories has approximately 200 technicians, or less than 10 percent of the total.

The work in the Research Laboratories Division is concerned with problems of the future. Usually the research projects are long range problems and not directed at any specific product already in production; in fact, research is the one group which is not concerned with the immediate problems of production, sales or service.

The work stems from a long list of general laboratory projects, each chosen to represent the types of work which the management believes will be important to the future of the company. This work is divided into main projects and subprojects, often totaling more than

## What Westinghouse Says:

**Based on an interview with J. A. HUTCHINSON, Vice President of Research, and A. C. MONTEITH, Vice President of Engineering**

FUNDAMENTAL RESEARCH is one of the basic factors contributing to the industrial growth and development not only of individual companies but of our entire economic system. Only by a continuing flow of new ideas can our standard of living be supported and the output of industry kept on a progressive incline.

Conversely, it must be obvious to even the most casual observer that a company which follows somebody else's lead becomes a deteriorating factor in its industry and takes a minority position in its markets. It is impossible for an outside concern to successfully duplicate, without a considerable investment, developments coming out of other research laboratories. It does not have access to vital information. The positive side of a development may be thoroughly discussed, but the negative side – mistakes, wrong theories, or troubles – usually are omitted or glossed over. Yet such data are invaluable for design and development.

Nor can a concern use only the research done under government sponsorship, much of which is performed in universities. First, very little money – contrary to opinion – is spent on basic research. Usually the sponsoring agency has a specific project, product or end result in mind. So while large amounts of money are being spent and patents resulting from such investments are public property, government sponsored investigations do not obviate the need for expanding programs in industry.

The small as well as the large company has an obligation both to its owners and to the people who buy its products to actively support research and to have men on its staff who keep abreast of scientific progress. Not every company can

# and Practices of Research

100 long-range problems. Any of the departments of the laboratories or several departments may be working on each of these projects.

Research projects must always be started years before they can be expected to result in a commercial product. The average time is usually from five to ten years between the laboratory experiment and the dealer's showroom. Consequently, there should be a sound economic reason to justify each project. After that, attention need be paid only to technical factors. Only a few of these projects may be successful, as far as the products are concerned, but in research it is necessary to be right only on a small percentage of the projects to make it worthwhile. If every project had to be a success, only those for which the answer was known would be chosen. This, of course, would be a low order of research.

The results of research are not a finished, manufactured product. They consist of written reports, working samples, instrumentation, new techniques, experienced personnel, new information, and patents. This is what is left after the work is completed. The results are then available to the manufacturing divisions.

Because of the decentralized organization of General Motors an operation has complete responsibility for its own products. Each manufacturing division accepts full control over the engineering design, as well as the manufacture, sale, and service of the products. The fact that there is no single authority on technical matters results in research, development and engineering problems being provided by central office staff to the production units.

The chart shows in an overall way how the engineering development, research and other technical groups are coordinated in the corporation. In some companies these groups are lumped together and called the engineering department, or the research department. As separate organizations, as they now stand, there may be a certain amount of overlapping in their work, but there is still much committees do not try to direct all the details of the investigations.

Although the general policies of the engineering and research departments go to the operating groups from the operations and financial policy committees by way of the president and vice presidents, the committees do not try to direct all the details of the investigations.

The Advanced Engineering section is a group whose work comprises the development and study of general engineering problems of all the

afford to invest several million dollars per year supporting a research laboratory, but there are few who cannot spend a few thousand on a project in their own particular field.

Initially, of course, a research program has to be accepted on faith that the ultimate results will pay off. Management cannot demand an accounting for every dollar that is spent. When a researcher starts an investigation or project, there is no assurance that he will obtain results that can be commercialized. The odds of doing so are probably somewhere between 1 in 10 and 1 in 100, depending on whether they are being quoted to management or among scientists. However, the rewards can be beyond expectation, as was the case with radio, television, the igniron, and the transitor.

In advanced development, of course, the odds are much closer to 1 to 1 that an investigation will pay

**A company must have faith in the ability of its research program to ultimately pay dividends. Over 25 years of effort went into research on television.**

## What GM Says . . .

manufacturing divisions. For an engine scheduled several years in the future, they would consider not only the general fundamentals of an advanced engine but its manufacturing problems as well. This section might be described as an engineering development group with much of its work overlapping production engineering and fundamental research.

Frequently, any one of the departments of the laboratories, or several departments, may be working on the general laboratory projects, and often four or five departments work on a single project. The mechanical engineering groups contribute their specialized facilities along with those of the chemical, metallurgical, and instrumentation groups. This method results in the greatest cooperation and has been found to be most successful. And, as one project generates another, personnel are urged to suggest new ones.

Projects are not always carried out in the same manner. Usually, developments are carried up to the point of proving a principle or establishing fundamental data. Then these fundamental data and results are turned over to one of the engineering departments of a manufacturing division to develop the production design. Projects like the Navy's sixteen cylinder pancake diesel, with a fully controllable pitch propeller, are the exceptions to the rule, and the development was carried almost to the production stage.

The research at General Motors is composed of a ratio of about 40-40-20, with 20 percent going for long range fundamental research, 40 percent for short term developments, and 40 percent service to the production divisions. This has proved to be a good division of the work over a long period of time. Most of the important developments come out of the long-range research, with the short term work being the method used to capitalize on the long range work. As it is impossible to operate an industrial research laboratory without doing some service work, the 40 percent service to the production divisions usually is in an advisory capacity to suggest a solution to a production problem.

***Research for Small Companies***

Small companies that maintain any kind of a research staff are forced to limit it to a small, select group rather than specialists in each phase of engineering. This is perhaps due in part to the large manpower requirements for applied research that have forced employers into competition with others offering positions in sales or operations in order to get a good man into research. This competition has brought the salaries of research in line.

The small companies without research departments frequently have colleges do some applied research for them. This is also true of the government, but not of big business. In the industrial research laboratories, the funds for research are limited; consequently, the course must be planned accordingly. It has been roughly estimated that a private concern would use one-third the money used by the government and still accomplish the same results.

## What Westinghouse Says . . .

dividends. The probability also is that the time lag between the start of the investigation and the production of an actual product will be much shorter than that between a research investigation and a product.

Before going further, perhaps it would be best to define, at least loosely, the difference between engineering and research. Some companies call advanced development or project development research, but for the purposes of this discussion, research will be defined as the search for scientific knowledge – a search for which there is no definite obligation or schedule. Engineering is the application of new scientific knowledge to the design and production of equipment.

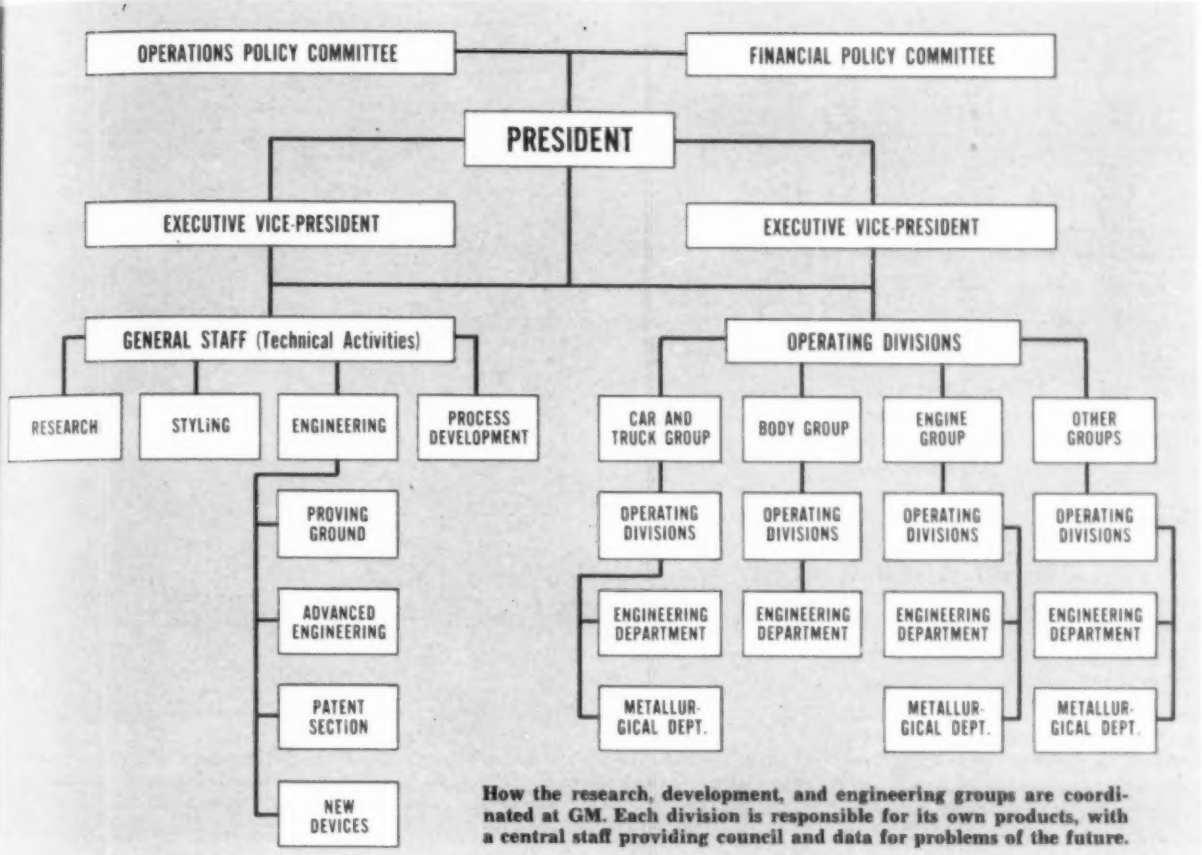
While there may be no particular schedule for completion of a research project – some "open end" products such as development of better magnetic or heat-resistant materials have been on the books for years and probably always will be–the main lines of endeavor must be laid out in advance by management. This can be done in two ways: formally or informally.

In a large company, the formal way usually consists of a program wherein the heads of the various engineering divisions submit a list of projects to the laboratory. These projects, which can be of any type or description, usually are checked and discussed individually and at a series of laboratory conferences. These conferences are followed by a formal meeting btween laboratory and engineering supervisors to discuss each of the problems.

Formal meetings give the engineering managers the opportunity to get a broad perspective of the problems, many of which may cut across divisional lines. They also give both parties an opportunity to suggest and criticize.

The second approach is the informal one that is so necessary for the successful functioning of any research program. If various division engineers periodically drop into the laboratory, a working relationship is established that is fully as important, if not more so, than the formal approach. In addition, if the heads of the various research projects get out to see the problems and physical state of the divisions, they obtain a better appreciation of the engineer's viewpoint.

In the final analysis, however, it is the research management that must decide which problems are the most important. The job of the research




**How the research, development, and engineering groups are coordinated at GM. Each division is responsible for its own products, with a central staff providing council and data for problems of the future.**

laboratory is to acquire the kind of scientific information on which a company can build and conduct its business. The viewpoint that is gotten in talking with engineering people is usually colored by the problem of today, but the fact that the same problems may come up year after year is indicative of the need for basic information. Realizing this, the researcher can establish a program in this general field. If information is forthcoming immediately, the company can use it; if not, they still will be able to profit from the knowledge forty years from now. That is why Westinghouse is putting a large percentage of its effort into projects for which there is no clear immediate application, but for which they foresee a need in the future.

On the other hand, the developmental engineering groups usually push on shorter range objectives. Often the dividing line between these groups and research is difficult to find, and rightfully so, for to function properly, the efforts of both must interlock. Actually, there should be a continuous flow of information from research laboratories right down through engineering to the end product.

One way of establishing such interrelations is by close cooperation, as discussed above. Another is by allowing the development engineer to do his own research when he so desires. When the materials, development, and central engineering laboratories are counted in, Westinghouse has over 100 locations in which research can be performed.

The amount of research done in these various areas depends on the type of men on the staffs. Some designers, when they come up against a basic problem, inaugurate their own program of investigation. Others will pass the problem to the research laboratories. The freedom to follow through on a problem must be given, within limits, to any man if he is to design and create.

The same freedom of action must also be given the researcher. If only the main lines of investigation are laid out by management and the details left to the scientist, results are certain to be forthcoming.

EDITOR'S NOTE: Research, even on a limited scale, may be an expensive undertaking and thus beyond the means of a small concern to support in their own plant. In this case, the company can underwrite projects in specialized fields with universities or with commercial laboratories such as: The Mellon Institute, Pittsburgh, Pa.; Armour Research Foundation, Chicago, Ill.; Battelle Memorial Institute, Columbus, Ohio; Southeastern Laboratories, Atlanta, Ga.; Southwest Research Institute, San Antonio, Texas; Stanford Research Institute, Palo Alto, Calif., or the Franklin Institute, Philadelphia, Pa.

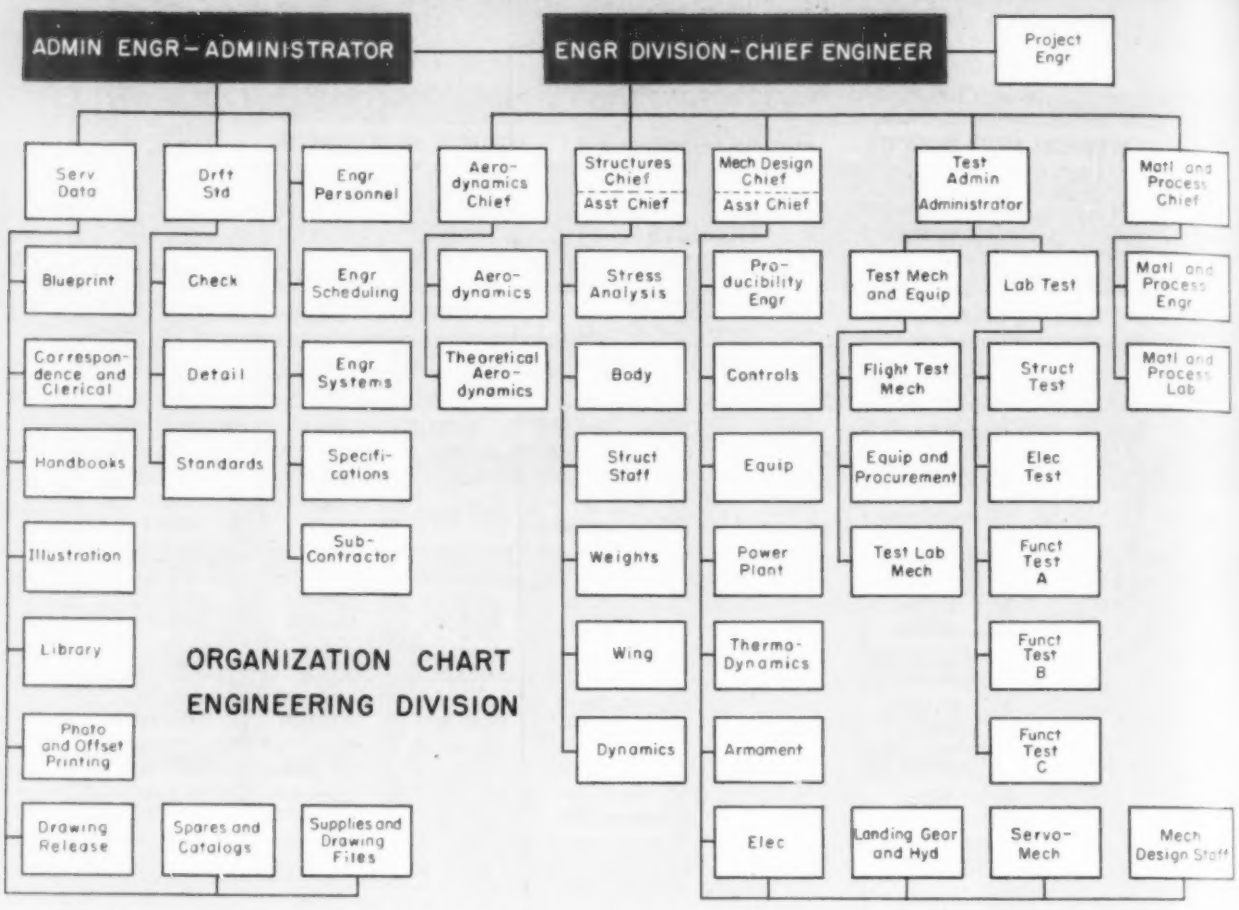



Fig. 1 (
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*The complexity of modern aircraft and its components has forced the evolvement of a new approach to design. Applicable to other complicated products, this method requires a special type of engineering department organization*

# Design Versus Development

**C. L. BATES**
**Chief, Mechanical Design**
**Northrop Aircraft, Inc.**

IN THE AIRCRAFT INDUSTRY as well as in certain other fields, the entire concept of design has given way to the concept of development. With this transition has come a consciousness of systems and system engineering brought about by the increasing complexity of the components that make up today's aircraft. Team development replaces the separate phases of research, design and post-design effort with a process encompassing all of them and combining them into a single progressive activity.

Product development in its newest sense includes the development of systems' components, the systems themselves, and finally the combination of these systems into the final product. Throughout the cycle there are five phases: (1) preliminary research; (2) design in the usual sense; (3) necessary technical analyses during the design phases; (4) adequate testing; (5) inevitable changes as the result of analysis and testing.

While design could be and frequently was largely a one man undertaking, development by its very nature is a team job. To accomplish this the engineering organization must provide an efficient development team.

### *Department Organization*

Organization of an engineering department as a development team is pictured in Fig. 1. Development responsibility is placed in functional groups with each handling its particular portion of the design or technical work for all airplanes.

This organization is the group system as contrasted to the project

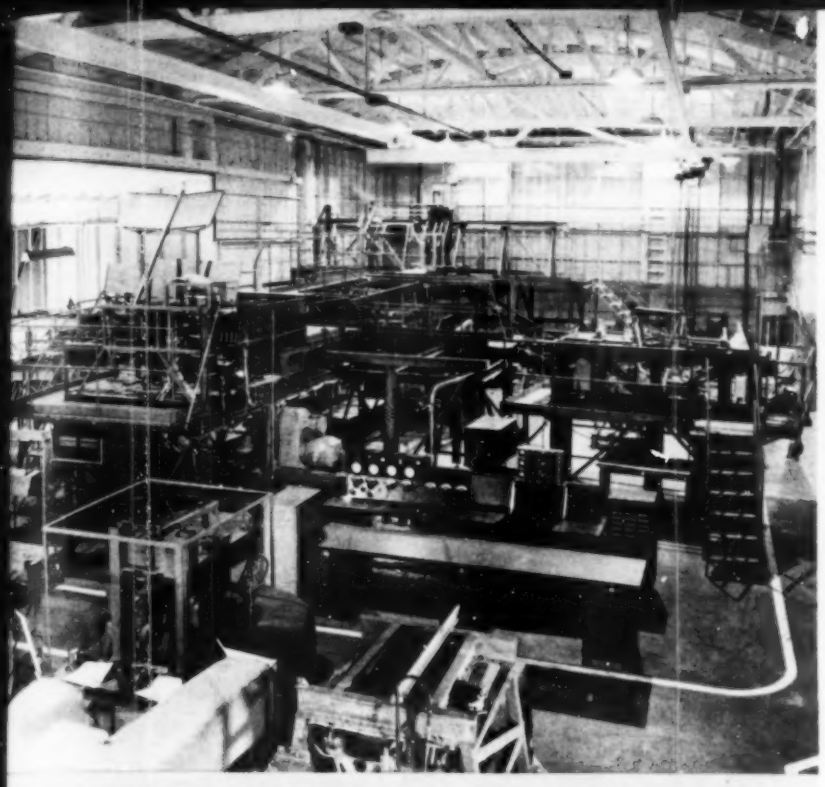


**Fig. 1 (Left) — Engineering Department organization chart of Northrop Aviation indicates how the department is set up for development effort. Sections are responsible for development work in their field for all airplanes.**

**Fig. 2 (Above) — Test stand for full power control system of one airplane completely occupies a building 60 x 60 feet. Testing done on this system required 68,700 hr. 53,000 hr were spent in design, and 79,000 hr in analysis.**

system used elsewhere in the aircraft industry where a project group is established with responsibility for all design phases of one airplane. There are arguments in favor of both systems and no company goes completely in one direction in practical operation.

In this particular engineering organization there are two main divisions: service groups supervised by an administrative engineer who is responsible to the chief engineer; and design and technical groups directly headed by the chief engineer. Eight design sections, an equivalent number of technical sections, and an ever-increasing number of service groups make up the engineering department, with the development work done primarily by the Design and Technical sections.

The sections are responsible to department heads. Those departments having design responsibility are: Aerodynamics, Structures, and Mechanical Design.

Basically, their responsibilities are broken down so that: Aerodynamics is responsible for the external shape and size of the airplane; Structures is responsible for the basic load carrying members; Mechanical Design is responsible for the remainder, including all equipment installations.

Project engineers have an important function in the group system. They are directly responsible to the Chief Engineer, and carry the full authority of that office on a project in all but strictly design decisions. These functions include all technical contacts with the customer and the engineering phases of contract administration. Having only one project to consider, the project engineer can devote his entire efforts to coordinating and expediting activities peculiar to that project.

Within the specialist groups are sub-groups that are responsible for the entire development within each specialized field. All work in thermodynamics is accomplished in the thermodynamics section, a typical technical section. Research projects are initiated and performed there; current design problems and technical analyses are carried on under the same supervisory staff. Technical responsibility for thermodynamic functions rests with this group from the original inception of a design until the airplane has finished its useful service life.

In the same way, a design section such as Controls carries out its assigned responsibilities which are entirely in the field of controls. These include varied activities of research, experimental design, and production design. By keeping functional and related responsibilities centered in specialist groups, it has been possible to maintain continuing design philosophies and to absorb new personnel with a minimum of effort and confusion.

Many discussions have advocated the desirability of segregating research activities from design by having separate sections, and even of separating experimental design from production design. While this has been done in certain long range projects, it is the writer's experience that many types of research, experimental design, and production design can be effectively carried out under the same supervisors with a noticeable improvement in both group morale and quality of design. An intimate association with current service and design problems has been a spur to research progress in both design and technical sections.

***Preliminary Design***

During preliminary design stages, personnel from the design and technical sections are brought together in a place designated as the preliminary design room. These men maintain their responsibility to their respective section supervisors who remain responsible for the technical excellence of their particular portion of design. While this group is a project task force for a particular airplane, each member has the advantage of the past know-how and the continuing research in his specific field of all the members of his section.

The work remains in preliminary design until: (a) all major design decisions have been made: (b) the group becomes so large that the advantages of a small closely knit group are lost; or (c) a more urgent job

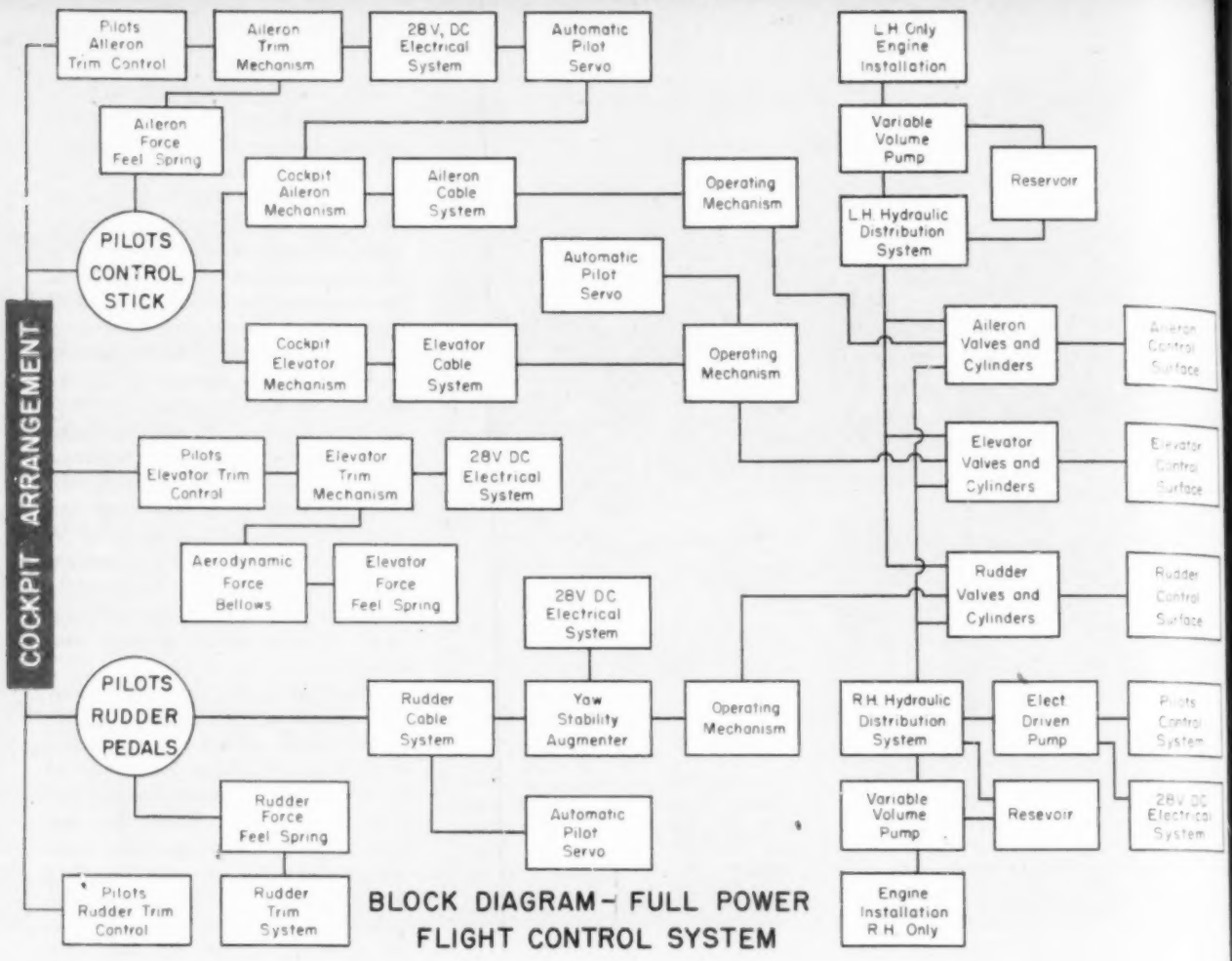



**Fig. 3 – Block diagram of the full power control system shows its relation to other systems in the airplane. Understanding relation of one system to others in the plane is the basis of system engineering. Some components of this control are systems themselves.**

replaces it in preliminary design. After leaving this stage, it is turned over to the design sections with the previously assigned engineers continuing with the project usually as lead engineers. In this way components and systems are kept compatable, since, for example, the electrical system engineers are aware of the trend of hydraulic and mechanical parts, and can proceed with their designs accordingly. Similarly, all the design groups involved are informed of each others plans and progress.

At this stage of development, one of the service groups takes over the important job of coordinating future work and reporting progress. The Planning and Scheduling Department is charged with the responsibility of preparing integrated schedules that indicate the dates on which technical data, test specifications, and other types of information will be required by the sections. This is an involved task that requires close collaboration of all the technical and design sections.

Progress reports to management are also the responsibility of this service section, and these reports are compiled from data supplied by the development sections using both hand prepared charts and business machine tapes.

Playing a new and important role in development is the Test Department. Testing, once considered to be primarily an evaluation procedure – a check on the design – now is recognized as an important phase in the development concept. Many testing programs which start out as evaluation tests become development problems before the tests have progressed very far.

Development testing in which tests are performed concurrently with the design as design aids is done on nearly every type of unit in the airplane – electronic units, mechanical parts, hydraulic valves and structural components, as well as the functional systems to which many of these parts belong. This procedure has become progressively more important during the past six years, and at present, fully twenty-five percent of the engineering department personnel are members of the Test Department.

Changes as a result of testing are to be expected and must be taken into account in time estimates and in schedules. Since these changes are an inherent part of the development in all but the simplest programs, failure to recognize them results in unmet schedules, higher costs and delayed production.

**Table I — Major Functional Systems of a Military Aircraft**

| | | | |
|---|---|---|---|
| 1. Aileron Controls | 18. Engine Installation | 35. Hydraulic System | 52. Radar Cooling |
| 2. Aileron Trim Controls | 19. Engine Mount & Hoist | 36. Hydraulic System — Emergency | 53. Radar Pressurization |
| 3. Air Conditioning | 20. Engine Ignition | 37. Induction System | 54. Radio Altimeter |
| 4. Anti-Icing | 21. Engine Starting | 38. Internal Lighting | 55. Rocket Fire Control Radar |
| 5. Anti-G Suit | 22. External Lighting | 39. Instrument System | 56. Rocket Fire Control System |
| 6. Auto Approach Coupler | 23. Fire Control Computer | 40. Interphone — Ground Crew | 57. Rocket Launching System |
| 7. Auto Pilot Controls | 24. Fire Extinguishing | 41. Interphone — Airplane | 58. Rudder Control |
| 8. Cockpit Arrangement | 25. Fire Detector | 42. Landing Gear Emergency Release | 59. Rudder Trim Control |
| 9. Communication Radio | 26. Flight Control Feel | 43. Landing Gear Control | 60. Single Point Fueling |
| 10. Crew Escape System | 27. Flap Control | 44. Landing Gear — Main | 61. Speed Brake Control |
| 11. Directional Reference | 28. Flap Control — Emergency | 45. Landing Gear — Nose | 62. Tactical Control System |
| 12. Ejection Seat | 29. Fuel Flow Indicating | 46. Lubrication & Oil Cooling | 63. Throttle & Afterburner Controls |
| 13. Electrical Power — AC | 30. Fuel Quantity Indicating | 47. Navigation Radio | 64. Visual Presentation (Pilot) |
| 14. Electrical Power — DC | 31. Fuel Purging | 48. Nose Wheel Steering | 65. Warning Signal System |
| 15. Elevator Control System | 32. Fuel System | 49. Optical Sight System | 66. Wheel Brakes |
| 16. Elevator Trim Control | 33. Fuel Vent System | 50. Oxygen System | 67. Wheel Brakes — Emergency |
| 17. Enclosure Controls | 34. Hydraulic Reservoir Heating | 51. Pilot Static System | 68. Windshield Defogging System |

***Application to System Engineering***

Specific application of team development to the evolution of a hypothetical military aircraft illustrates how this technique operates during design.

First step in the preliminary design involves setting up the systems which will be required to produce an airplane capable of accomplishing the required mission. Table I lists the major functional systems of such an aircraft, and illustrates the complexity of this job.

Preliminary research on a system involves an analysis of basic concepts and new ideas applied to an old problem. For instance in starting the development of the autopilot system for a new airplane, engineers ask: is it necessary to tie the system to vertical and rate gyros, as has become customary in the autopilot field? Are there other stability derivatives than those customarily used which will permit stabilization of the airplane as well or better? Can some new approach to the whole problem be used? These are research-type questions and require research for their solution.

After questions such as these have been answered and fundamental principles have been established, basic development problems can be attacked.

If research were to determine that an accelerometer can be used to measure side force and that this will be used to sense side slip, the development proceeds along the line: What accelerometers are available? What principles can be used to develop an accelerometer with the required sensitivity and threshold values?

This portion of the development is accomplished in preliminary design under the direction of the servomechanisms section. When the system leaves there, it will be fairly well specified and the actual hardware stage will be reached. The major items of the system, including the airframe, hydraulic systems, the cable system and perhaps even the servo motors will be known values. The characteristics required of the "black boxes" (electronic devices and controls) are derived from the functional analysis, as the system is synthesized to meet the specified characteristics.

During the "design in the usual sense" phase after leaving preliminary design: Aerodynamics must supply the stability derivatives; Weight section maintain weight control; Electrical and Equipment prepare for their installation problems; Hydraulics may be involved in new valve designs; and Controls carry a major load in control system and component design.

Structural component development requires the closest coordination between the engineering department and the shop, because it involves specialized personnel and methods. No matter how carefully the original design is executed, design changes will be dictated by revised tooling methods, material changes or new processes that lead to cheaper production.

Testing as an important and integral part of team development is done on both systems and components. Tests become extremely involved since it is essential that environmental conditions be correctly represented. These conditions must be produced or simulated if the ground testing is to be adequate. Fig. 2 illustrates a full-power control system test stand for one airplane design.

An example of environmental testing in component development is represented by one hydraulic control valve. With requirements so severe that hydraulic control companies declined to bid on the job, design had to be accomplished at the home plant. This valve involved a sleeve with a number of drilled holes, each 0.013 in. in diameter. As a result of test stand operation, a number of changes were made to improve operation. One such change involved the broaching of a "V" slot along one side of two of these very small holes and the development of the tooling to accomplish this.

Final system check of an airplane comes in flight testing. This is very expensive, so for obvious reasons, as much testing as possible is done on the ground. An important phase of flight testing is pilot reaction since some systems are designed primarily for pilot acceptance . . . to give the pilot the control feel he desires.

The final chapter in development is the complete airplane being tested full scale under its own power in the environment for which it was developed. More changes result from the flight program. Once these are incorporated, the plane is ready.

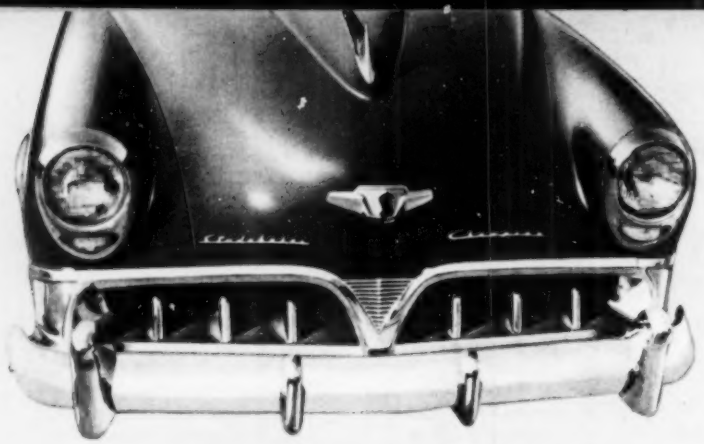


**Fig 1 (above) – Based on cost of previous designs and knowledge of the manufacturing changes required for a new bumper, the cost engineer can make a preliminary estimate that is accurate within a few cents of the final figure. Fig 2 (right) – Preliminary cost analysis prior to finishing design enables Studebaker to obtain better comparison on component designs, such as on the water pump shown here. This prevents setting up uneconomical designs.**

# ONE SOLUTION to Design Bottlenecks: Special Engineering Groups

WHILE THE USE OF CONSULTANTS or consulting groups is an established principle in engineering department operation, new conceptions in purpose and function are currently being introduced. Instead of dealing with design or production problems such as metallurgy, electrical control, or standards, these groups are concerning themselves with engineering budget control, experimental purchasing and specification, engineering procedures, and other phases of operation that have received only incidental attention in the past.

For example, an integral part of Studebaker's engineering department is a consultant who concentrates on the estimation and reduction of costs in new models and components. There is a rigid rule that no decision is made on the engineering or appearance qualifications of new designs, whether it be an entirely new body or only a water pump or bumper, unless there are accurate estimates of purchasing or manufacturing costs on each. When the research department and the designers are plugging for improved quality and performance, the cost engineer contributes a big "but." The result is always a compromise although frequently on the side of improved performance, but the decision is a much more intelligent one than if cost figures were unavailable. In the long run, a design that is not economical may be fatal.

The procedure on a new model is as follows: the engineering department supplies the styling section with the salient dimensions and specifications – height of top and bottom frame, length and height of hood line, overall length of car, front and rear seat height – from which a buckboard drawing is made. Sketches of new models are then prepared, from which 2 or 4 designs are approved into the clay model stage.

From this point, the engineering cost analyst works closely with the styling section, the engineering department, and the shop to check piece costs. Both major and minor items affected by the change are listed, checked for weight, old cost and new cost. The cost engineers follow through on all items until management makes a decision on which model to produce and all changes are made, and may act as a liaison between engineering, the shop and outside suppliers.

All preliminary analysis is based on the experience of the cost engineer, who in turn bases his estimate on former piece part costs, material costs, and a background of experience in production methods. Studebaker has found that this preliminary cost analysis has several advantages: (1) the engineering department has an expert's opinion on the cost of changes, and therefore more data on which to base a decision; (2) it has closer contact with suppliers and with the shop; and (3) changes can be made to lower cost before parts are put into production.

### *Engineering Budgeting Control*

Closely allied with product cost is the problem of engineering budget-

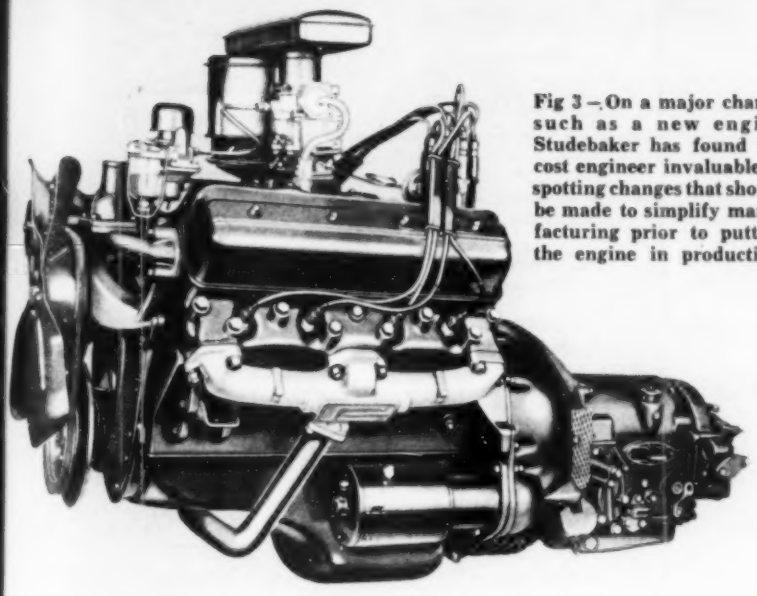


**Fig 3 – On a major change such as a new engine Studebaker has found the cost engineer invaluable in spotting changes that should be made to simplify manufacturing prior to putting the engine in production.**

*Many companies have found that engineering groups concentrating on such problems as budgeting, new model cost, future development, purchasing, production, or special design not only relieve confusion and improve efficiency but provide a sounder base for the development of new equipment.*

ing. All concerns establish an engineering budget that is broken down into allotments for various projects, but the system in use at the Wright Aeronautical Division of Curtiss-Wright, Wood-Ridge, New Jersey, goes farther than that; it insures follow-up at periodic intervals to determine if more or less of the allotted money is being spent as directed; if the relationships of the elements of cost are fluctuating, and if so why; if there are bottlenecks in the delivery of experimental parts by suppliers; if the funds allocated for research and development contracts are properly expended; and other aspects of Engineering Department costs.

This is done by a budgeting division that is a part of the engineering department, Fig. 4, and reports to the Director of Contracts and Schedules. It keeps track of expenditures by engineering projects and services. Ordinarily once such costs go to the accounting department, they are charged into various accounts and a special analysis of these accounts must be performed to obtain operating information. For example, depending on the method of computing the cost of production sales, the entire engineering department costs may be carried as an overhead item corporate-wise and detailed information would not be available from the usual financial publications.

The budgets are established at the beginning of each fiscal year and are broken down by type of engine and models – reciprocating, turbine, or non-rotating – and then further split into design engineering costs, and experimental costs. Design engineering costs are the costs of keeping present day engines in an advanced state of development and of correcting conditions that may occur in the field. These include not only engineering and supervisory salaries, but also overhead charges for stationery and office supplies, travelling expenses, etc. Experimental engineering costs are incurred as a result of specific developmental contracts with the military or as a result of funds appropriated by management. The charges under either of these funds are apportioned as follows:

Design Engineering Costs
1. Drafting Salaries
2. Engineering Salaries
3. Laboratory technicians salaries
4. Overhead – supervisory and clerical, stationery and office supplies, laboratory supplies, traveling expenses.

Experimental Engineering Costs
1. Direct materials
2. Direct wage labor
3. Overhead – supervisory and indirect labor, test equipment maintenance, special tooling, amortization, general manufacturing expenses, supplies and services.

Each project in the budget is given an engineering project authority (EPA) number, which is indicated on every work order and is coded so that the charges are made against design or experimental costs.

To maintain current examination of expenditures, accounting records lag by approximately one month, the engineering department accumulates data relating to direct salaries and labor in several different ways; daily tabulating of assembly and test direct labor, and engineering salaries from job reports which are turned in every pay period. Reliable current estimates of total cost can be computed by adding overhead as a fixed percentage to the direct salary and labor costs based on past experience, and purchase costs are accumulated from receiving reports against purchase orders.

Totals of the above data are used in various ways for control. Accumulated hours under each EPA are plotted against budget schedules to obtain an index of progress. A continuous open purchase order commitment, which is cumulative is maintained for each major project. Curves can be plotted of these commitments vs. vendor payments to spot bottlenecks in delivery of experimental parts.

To maintain a balance among the elements of engineering cost such as drafting, engineering salaries, and experimental labor, these costs are plotted against the total engineering

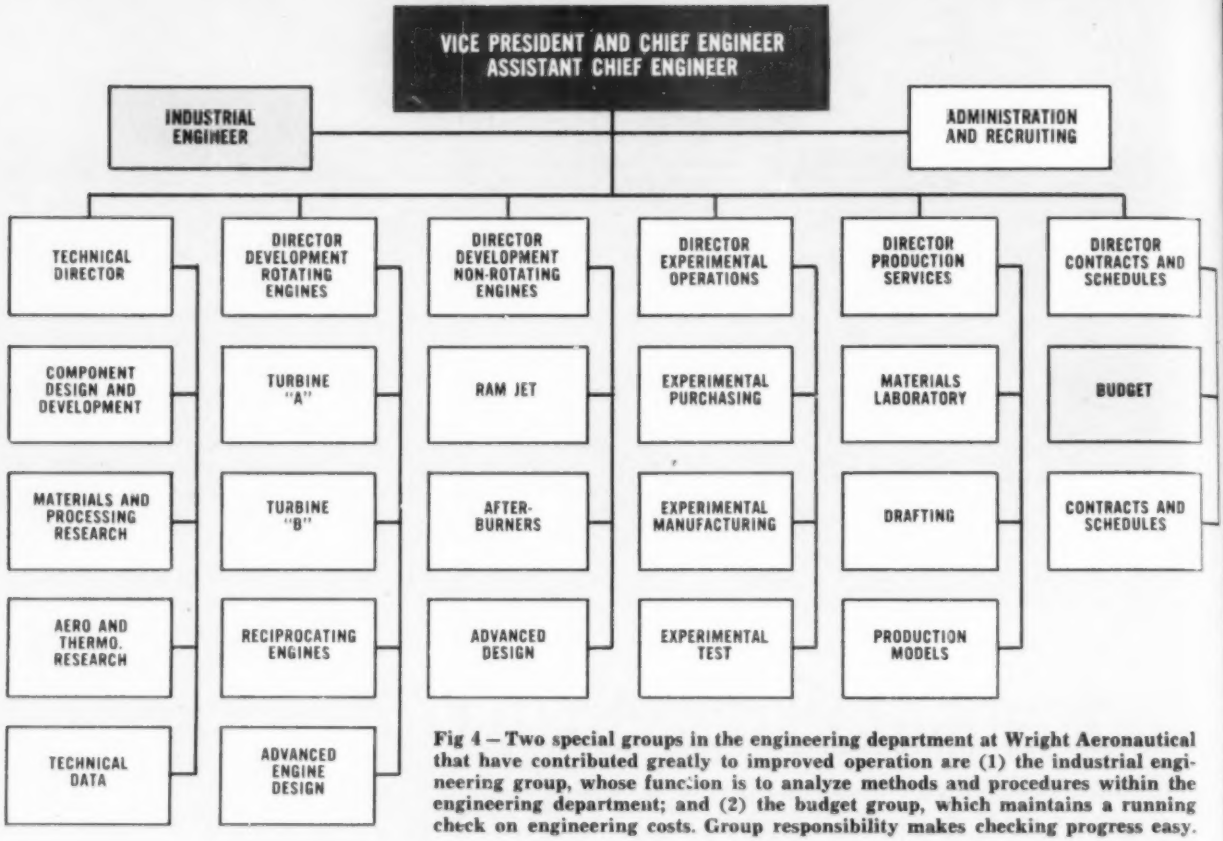



**Fig 4 — Two special groups in the engineering department at Wright Aeronautical that have contributed greatly to improved operation are (1) the industrial engineering group, whose function is to analyze methods and procedures within the engineering department; and (2) the budget group, which maintains a running check on engineering costs. Group responsibility makes checking progress easy.**

charges (less purchasing costs). Purchasing costs are deducted from total engineering cost because one engineer with a sizable requisition can throw the whole picture out of focus. These relationships for the department as a whole should remain fairly stable over a long period of time.

These and other charts, Figs. 5 and 6, are used strictly for engineering control purposes. They are entirely separate from normal accounting operations, and the breakdown of costs is purposely kept simple so that very little manpower is needed for measurement and so that the results are usable by the affected engineers.

### *Industrial Engineering Staff in the Engineering Department*

Another innovation at this aircraft engine company is the establishment of an industrial engineering group within the engineering department. This group is charged with the responsibility of constantly reviewing methods within the department and recommending procedures that will result in higher efficiency. Such practices as engineering change notices, departmental organization, and other management phases of engineering are constantly under their scrutiny, and since they report directly to the Vice President and Chief Engineer through the assistant chief engineer, their recommendations usually receive immediate attention.

An example of how organization may be changed to promote improved operations is illustrated by the organization chart, Fig. 4. Formerly, there were fourteen operating divisions under the chief engineer and the assistant chief engineer, each reporting individually on problems and progress. The result was that some problems were not given adequate attention, while others received too much.

With the new setup, there are only six engineering executives reporting directly to the vice president and chief engineer. Responsibility has been grouped and correlated so that not only the chief engineering executive but also the department executives can keep a better check on progress and development.

### *Purchasing Groups in Engineering*

Many concerns have discovered within the past few years that there are advantages to having trained engineers in the purchasing department or in having trained purchasing agents who are engineers in the engineering department. For example, one of the large appliance manufacturers in the country has two men whose jobs are to maintain constant contact with suppliers. These engineers not only keep an eye on the lead time required on the ordering of components but also, through intimate contact, get a good idea of the developments that are coming along in the suppliers plants that might be applied to their products.

Secondly, some companies are discovering that the lag time on parts and equipment for their research and development programs is constantly increasing. The reason for this, of course, is that the main job of the purchasing department is to keep the factory in operation, so that developmental parts do not receive the attention they require. In this case, a separate purchasing de-

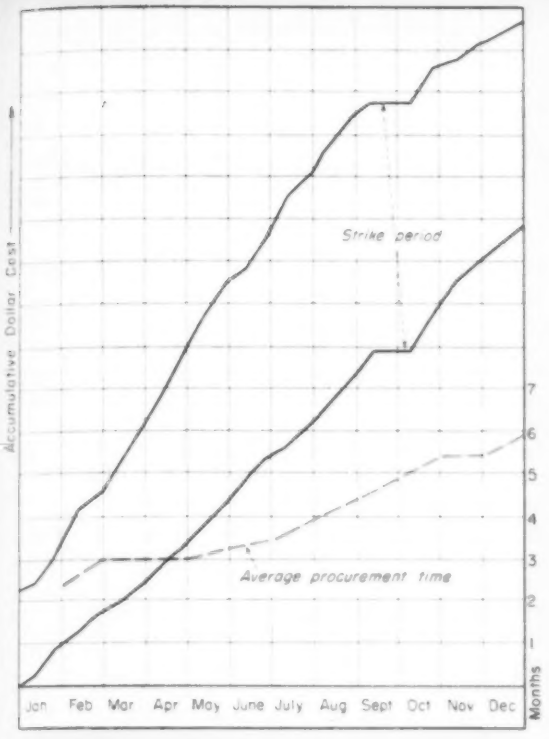
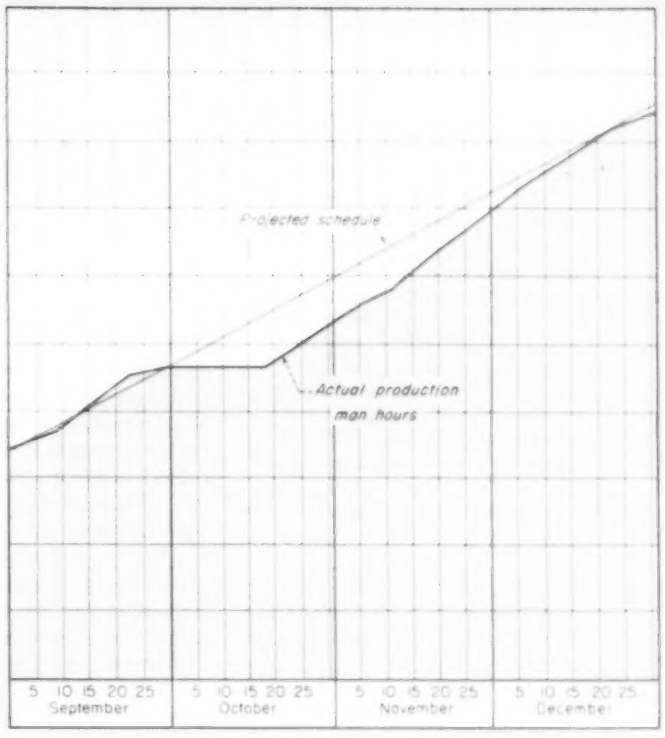



**Fig 5 (left) — By plotting dollar commitments for experimental parts versus value of parts delivered, the budget section can spot trends in procurement and take corrective measures. Diverging lines represent a deterioration.**


Projected schedule
Actual production man hours
5 10 15 20 25 September
5 10 15 20 25 October
5 10 15 20 25 November
5 10 15 20 25 December

**Horizontal distances between lines give average procurement time in months. Fig 6 (right) — Experimental machine shop schedule vs. actual production in manhours. Plot shows bottlenecks and needs for additional capacity.**

partment consisting either of an engineer or a trained purchasing executive can be attached to the engineering department to handle the job.

Finally, in times like these, an engineer may find that his specifications call for a part that is not available. If this is the case, it may mean that the entire design has to be re-figured or re-drawn. Consequently, one approach that is being used by the Lincoln Electric Company is to leave final specifications off of all drawings until trained engineers who are attached to a purchasing group in the engineering department can check with suppliers to determine availability. In other words, specifications are written only after the engineering department knows what can be obtained.

### *Computer Sections*

More and more companies are discovering that they can save a great deal of engineering time and effort by establishing mathematical sections within the engineering department. Generally, these consist of trained mathematicians who are adept at handling various types of numerical and analogue computers. This trend started in the aircraft industry, where problems with an infinite number of variables are adaptable to computing machines. It has spread however to the automotive industry, and several large automotive manufacturers have now established computing divisions. One of the latest is the Chrysler Corporation.

### *Future Development Section*

Companies who have established research divisions often find that there is a considerable gap between research and engineering. Very little of the research output may be directly applicable to the designer in development work, whether the research is basic or of a developmental nature. General engineering laboratories usually attempt to convert that output into materials that can be used by the designer, but sometimes this is a difficult procedure. One company has solved this problem by setting up a Future Development Section, whose job it is to foresee markets and develop equipment to meet those markets.

The advantage of this section is that it takes long range problems away from the engineering department, where day-by-day problems generally require all the effort. The objective is new equipment that will far ahead of competition.

Another step is to fill in the product gap where no product has previously been practical. For example, if an electric motor were to be developed that had to operate at 400 C ambient, some strange phenomenom might occur, such as electrical creep, about which there is very little engineering theory. Insulation, bearings, greases, and finishes would all be problems. The answer to these problems may be in the research lab, but long range development sections would have to put them all together into a motor that then could be taken over by the product designer. Generally, these long range development groups are not interested in cost. The line development group or project engineer is. His problems are still difficult but much closer to practical solution than before.

# Templets + Photography

F. L. TEUSCHER, Industry Control Department, General Electric Company

*Editor's Note* – **A significant phase of the growing revolution in drafting room practices is the use of photographic methods for the production of electrical and mechanical drawings. These "photographic drawings" are uniform, have an excellent appearance, and can be made quickly and with a high degree of accuracy. They typify a trend toward the streamlining of engineering department procedures, and provide a field for investigation that many manufacturers could profitably explore.**

DURING A PERIOD in which the major phases of engineering work have advanced at a rapid pace, certain associated phases such as drafting techniques and drawing reproduction have been practically dormant. Perhaps the reason is that these associated phases have always been looked upon as engineering services. Whatever the reason, the reproduction of engineering layouts and drawings has continued to be done by methods easily recognizable to three generations of engineers; and it is significant that only recently has sufficient engineering talent been applied to accomplish changes and obtain progressive results.

Thus photographic reproduction of drawings has received considerable attention and has been recognized as being superior to conventional techniques under certain circumstances. Templets have been combined with photography to actually produce original drawings. Now all control panel electrical and mechanical drawings are being made in this manner in the Industry Control Department of the General Electric Company at Schenectady. The result has been that more drawings of greater uniformity are produced and at lower cost.

Briefly, the procedure consists of using steel symbolets—so named be-

**Fig. 1 – Master drawings of contactors, relays, resistors, switches, fuses, and other components first are drawn full scale on tracing paper.**

**Fig 2 – Drawings are reproduced at a reduced scale on steel plates, called symbolets, which are then filed systematically under headings of equipment they represent.**

**Fig 4 – Layouts are photographed with two fixed focus cameras. One negative is used to make drilling templets; the other, is used for the electrical drawings.**

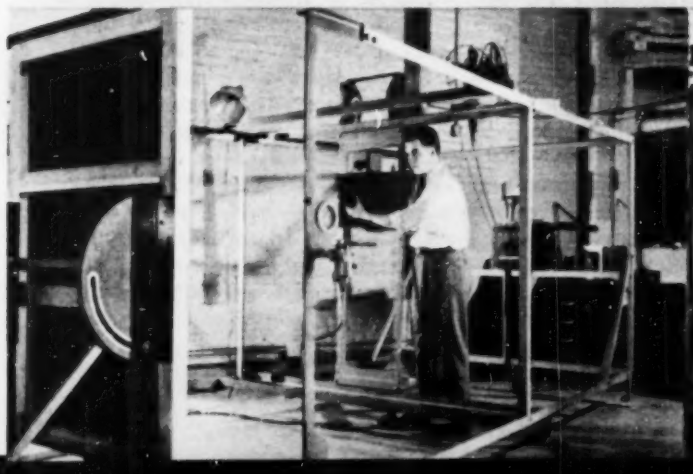
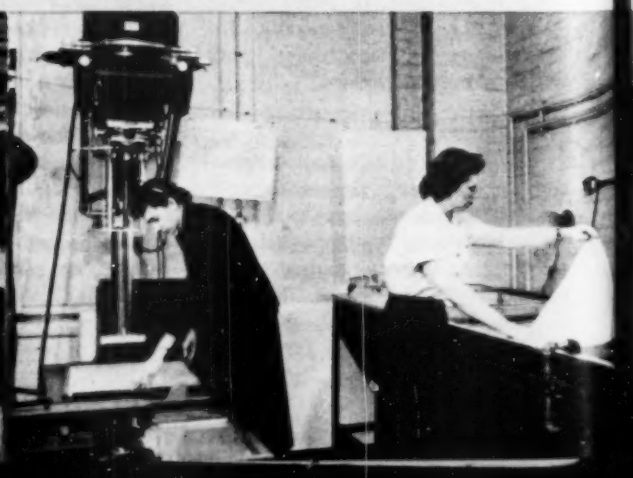


**Fig 5 – Negatives are processed in a darkroom and enlarged to produce electrical drawings on photosensitive tracing cloth. The exposure time of the enlarger is fixed.**



# Low Cost Drawings

cause of their similarity to symbols and templets—on a magnetic layout board, photographing the layout, and printing the drawing on photosensitive tracing paper (Figs. 1 to 6). It is being used for both electrical and mechanical drawings.

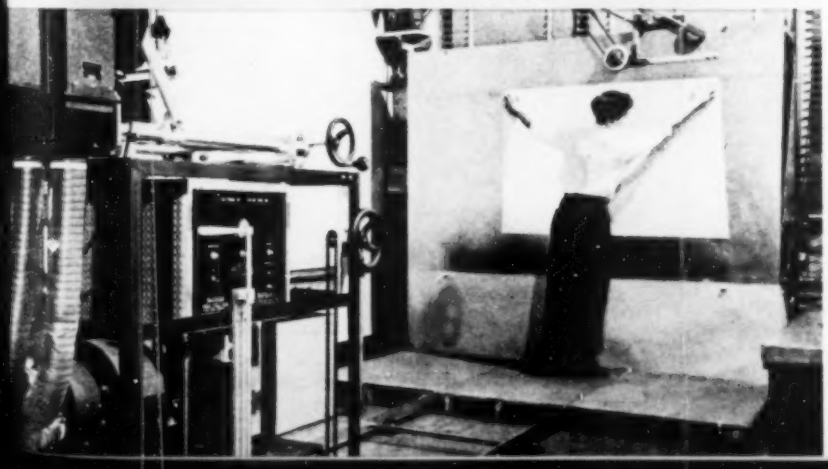
### *Electrical Drawings*

This method of producing drawings has made possible a new electrical connection diagram that is to scale. On previous conventional drawings the composite symbol arrangement did not indicate clearances or correct relative heights for the electrical devices and was not a true picture of the actual panel layout. The difficulty in interpreting the old type diagram may be compared to that of understanding a mechanical drawing that is completely out of proportion. The symbol was strictly an electrical representation and did not illustrate mechanical details. For example, it did not show whether a connection stud or terminal was located on the front of the panel or on the back.

The new type of connection diagram that has been developed overcomes these undesirable features by providing an accurate and completely detailed scale representation of the panel. The arrangement and size of symbols agree exactly with the layout of devices on the panel as manufactured. Relative heights, length of wire runs, and location of studs and terminals can be scaled directly from the diagram.

**Fig 3—Symbolets are used to make layouts by placing them within borders representing equipment housing. They are held in place by Alnico magnets that are screwed on 1 in. centers into the layout board.**

**Fig 6—Base drilling templets are made by projecting the film negative to full size. Both the mechanical and the electrical details of the layout are shown on this negative. It is at this point that tracings are made for the shop.**



For electrical connection diagrams, the symbolet is essentially an electrical symbol which has been superimposed upon the drilling plan for an electrical device such as a relay or contactor. On mechanical drawings, a symbolet represents an assembly or a detailed part and may include complete dimensions. It may simply be a note or set of instructions. The only requirement is that this "building block" be one that can be used over and over again. (See Fig. 11.)

The scale symbols are true representations of the devices and components. The photographs of Fig. 9 (A) show front and back views of a 100-ampere d-c power contactor. Note the close similarity between these photographs and the new symbol Fig. 7 (B). The electrical portion of the symbol is always shown attached to the appropriate conection terminals; the illustration Fig. 7 (B) indicates that the top and bottom power connections are respectively vertical and horizontal bars extending through holes in the base. The photographs show also that the interlock and coil terminals are located on the front of the panel and are wired through lead holes. The symbol portrays this information by the broken line extending from the lead hole to the solid dot designating the coil or interlock terminal.

In the preparation of the symbolet, a master drawing is first made and reproduced on steel plates. The housing, the electrical symbol, and the mounting holes are printed in black on a white background. Hole sizes and other drilling data are printed in blue. When the photograph is made for the preparation of the drilling templet, a filter is used which permits the recording of the information in black and in color. For the preparation of a connection diagram or mechanical drawing, a filter is used to suppress the detail that is in color.

On the back wired panel, Fig. 7, outlines for components mounted on the front of the panel are shown dotted; solid outlines denote rear of panel mounting. This feature permits panel assembly directly from the connection diagram and obviates the need for separate sketches or draw-

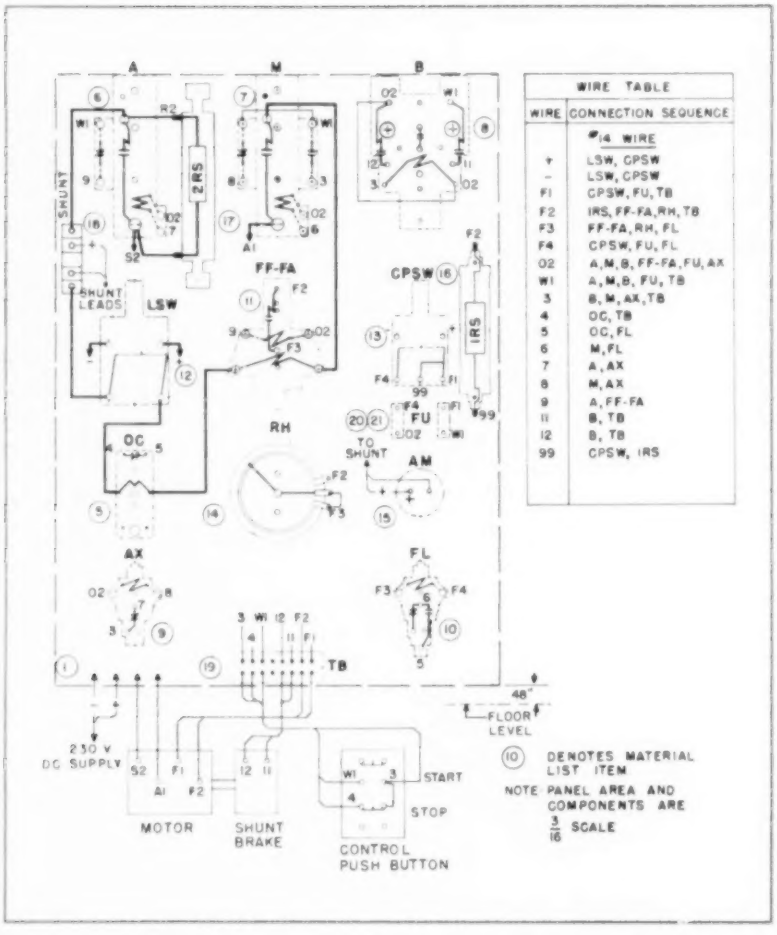



**Fig 7 – Electrical connection diagram for a control panel made by photographic methods. On this "wireless" wiring diagram, connections are numbered after the drawing is made. Outlines of equipment that is mounted on the front of the panel are shown by dotted lines. Solid lines indicate back mounting.**

ings. The encircled numbers adjacent to device symbols denote material list item numbers.

The scale connection diagram illustrated in Fig. 7 is the wireless type. There are no control wires drawn in, only the power leads. The elimination of lines denoting control wires reduces congestion and makes the diagram easier to read. The wireless diagram utilizes a "wire table" which is a complete listing of all control wires arranged in numerical order. Opposite each wire number are listed the designations of all devices connected by that wire. On the panel section, each wire number is shown adjacent to the connection stud or terminal on the device to which it connects. A wire run can be quickly followed by referring to the wire table and the numbered symbols.

In the wire table of the new scale diagram the device designations for each wire are listed in the proper wiring sequence – that is, the successive order in which all devices are to be connected. The scale diagram makes this possible because the shortest wiring path is easily determined from the scaled layout. This feature is advantageous in that (1) the connection diagram prescribes to the manufacturing organization exactly how the panel is to be wired and (2) wire tracing during installation or maintenance of the control equipment is easier because the diagram agrees exactly with the actual

**Fig 8 – Mechanical drawing used to show mounting details on panel enclosures, operating stations, or control desks. Layout is facilitated by numbered lines showing distances along horizontal and vertical axes from a corner location.**

panel wiring. The scale diagram is a valuable record of the physical as well as the electrical properties of the panel.

In addition to connection diagrams, this photographic reproduction process can be applied to the construction of interconnection diagrams without additional changes. Symbols for the motor, brake, and pushbutton shown in Fig. 8 are reproduced in the same manner as the panel devices.

### *Mechanical Drawings*

As a further expansion of the photographic reproduction scheme, a process for reproducing a new type of low cost mechanical drawing for use on sheet metal components has been developed.

This is illustrated in Fig. 8, which shows a layout for a mechanical drawing that is to be used for drilling or modifying the doors of panel enclosures, operating stations or control desks. These modifications are for adding various arrangements of meters, pushbuttons, rheostats, indicating lights, selector switches, and other components necessary to meet the specific requirements of the user of control equipment.

A mat or grid is made to represent the steel work of the the door; the area which corresponds to the front of the door is cross sectioned with horizontal and vertical lines spaced one half inch apart. These lines are also numbered at half inch intervals. Symbolets for the door components are located on the desired center lines. All dimensions on the mat that do not apply to any of the components are deleted by covering them up with pieces of metal that have been painted white. This layout is photographed and reproduced on sensitized tracing cloth. Often the only hand lettering or writing that is required is the approval signature.

As can readily be seen, this type of drawing can be laid out in a matter of minutes and errors are practically eliminated. Layouts are greatly facil-

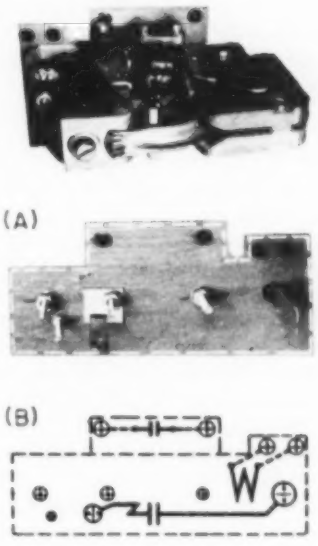



**Fig 9 – A 100-amp d-c power contactor shown (A) photographically and (B) by the corresponding symbolet.**

## Short Notes on Drafting Room Short Cuts

• • • Printed drawings rather than inked tracings or pencil sketches are being used by many concerns for standardized housings or components that vary only in overall size or minor detail. Title blocks, margins, and detailed notes are included. Overall or critical dimensions that change from job to job are the only additions that have to be made by the draftsman when he enters the job number and customer name on the drawings.

• • • Typewriters with adjustable size type, such as the Varitype on IBM machines are being moved into the drafting room for the preparation of drawing notes. The obvious savings in time on the part of skilled drafting personnel more than offsets the cost of the equipment.

• • • One of the booming drafting room techniques involves the use of "Stanpats" made by the Stanpat Company of Whitestone, New York. These are drawings that are printed on transparent paper that is coated, front and/or back, with an adhesive. They can be used in much the same way as the Symbolets described in Mr. Teuscher's article except that the forms are pressed out on standard size drafting paper instead of being placed on a layout board. For example, the elevation view of standard pumps, valves, reservoirs, and other components might be kept on file for hydraulic layouts. Only connecting lines and dimensions, if any, need to be added once a layout is made. Running the layout through a blueprint machine fuses on the Stanpat.

• • • Light blue or brown guide lines on drafting paper facilitate layout, yet will not show on a blueprint. Practice varies, but often this is done by a local printer when title blocks and margins are being printed.

• • • Three dimensional drawings are replacing top, side, and elevation views in plants of many of the process equipment manufacturers, and of course have been used for many years by the mass production industries to instruct shop personnel in assembly and manufacturing methods. Large concerns can arrange for instruction in the various techniques in their own plants. Smaller concerns have successfully pooled facilities with other companies of the same size, or have paid for weekly classes at local trade schools or universities.

• • • Celluloid or plastic templets of bolt heads, piping connections, and widely used electrical and mechanical components are being used by the aircraft and certain other industries to cut down on the amount of time required to detail a drawing. Such templets are inexpensive, particularly if stamped from plastic sheet in a plastic job shop.

• • • The value of standards is well established, not only as an aid in design but also in the shop and stockroom. With taxes at high levels, now is the time to invest in the development of standards manuals, even though engineering departments are overloaded with new design projects. For the same reason, the time was never more opportune for the replacement of obsolete drafting room equipment.

• • • The day of finely inked drawings is rapidly passing in many industries – if it already hasn't passed. One of the largest chemical engineering concerns in the country discontinued such practice ten years ago. And in certain specialized manufacturing plants, sketches are replacing pencil drawings for the shop.

itated because the symbolets are to scale, and the resultant drawing is particularly useful when coordinate type punch presses are available in the shop.

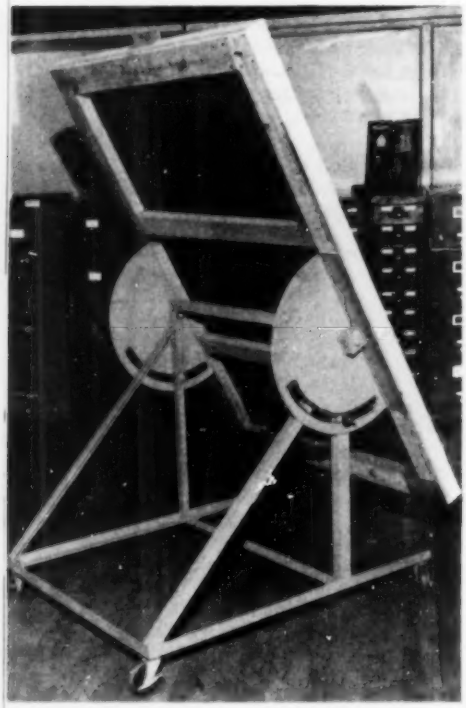
### *Layout and Reproduction Equipment*

The equipment in the drafting room and the reproduction facilities were especially selected for flexibility and accuracy. The layout boards are constructed of wood, and the Alnico magnets that hold the symbolets in place are embedded beneath the surface. For electrical layouts these boards, which measure approximately 4 x 6 ft, are covered with a plastic coated cloth on which cross sectional lines have been printed.

The supporting framework for the board is constructed of steel sheet and angles, and is equipped with casters so that it can be rolled from the point of layout to the camera. It is so designed, Fig 10, that the board can be tilted through a 90 deg arc from a horizontal to a vertical position.

After the layout work has been completed, the board is tilted to a vertical position and clamped to the camera framework. The board is then in a fixed position with respect to the cameras.

**Fig 10 – Construction details of layout tables. The layout board can be tilted from a flat to a vertical position.**



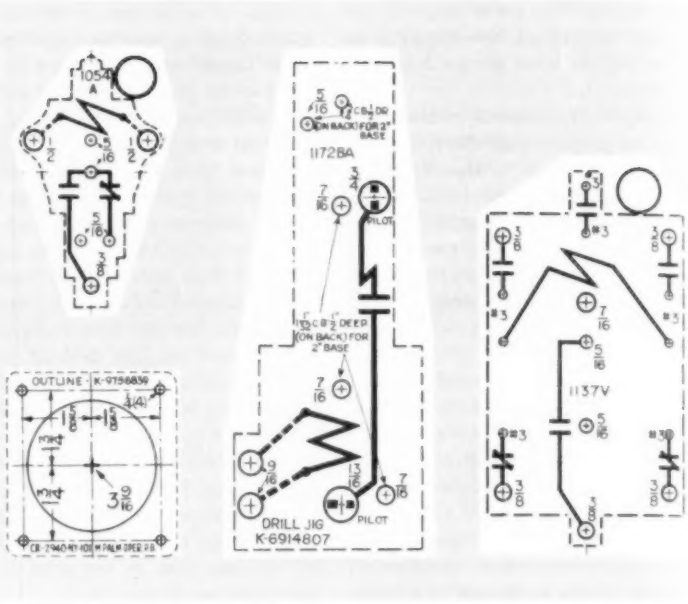



**Fig 11 – Typical symbolet drawings for contactors and relays. These drawings are then reproduced on steel. The one at left is for mechanical detail.**

To isolate building vibration during the exposure, the camera framework is mounted on rubber pads. In addition, the layout board is clamped in a supporting frame that is further isolated from the main framework by two air cylinders. When pressure is applied to these air cylinders, the auxiliary frame raises the layout board and frees it from the table carriage.

Two fixed focus cameras are employed, each being a box type constructed of Textolite, which has high thermal stability. Both the forward camera, which is used to photograph sections of the layout for sheet metal layout, and the back camera, which is equipped with a filter to remove the mechanical details that are printed in blue on the symbolets, can be rolled from one side of the framework to the other. High grade lenses are used on each.

The photoflood lighting and the length of film exposure on each are controlled by an automatic timer and operated by magnetic switches. Thus the amount of light and exposure time are uniform for all layouts.

A darkroom is available with the necessary equipment for developing the film and an enlarger for making the tracing cloth reproductions. Here again automatic timing devices are utilized in the various steps of photographic processing, and automatic controls are used to control the processing baths at a constant temperature of 68 F. The entire procedure has been standardized and controlled to the extent that it is not necessary for personnel to have had previous photographic experience.

Templets for sheet metal layout are drawn from a projection of the layout. A precision type enlarger is used to project the templet negatives to the full base size. The equipment is suitable for making paper base drilling templets for bases up to 4 x 7½ ft with an error of 1/32 in. or less over the entire area.

Reproduction of the projection is done by a draftsman who works on a vertical layout board. The enlarger, which is equipped with a high wattage mercury projection lamp, is air cooled and mounted on tracks so that, by proper positioning certain sections of the drawing can be traced. (See Fig. 6 for details.)

Besides being used for the above purposes, the photographic principle can be applied to almost any type of drafting work. The use of such methods as a replacement for conventional drafting procedures is a well founded, acceptable, money-saving process.

# Control of Paperwork in Engineering

R. H. **ESHELMAN**, Procedures Analyst, Engineering Staff, Ford Motor Company

*Ways for cutting the excessive volume of paperwork associated with engineering department operation. Methods for channeling the flow of engineering information more effectively toward productive results. Benefits obtainable through method surveys, procedures analysis, and forms control.*

ONE HEADACHE all engineers have in common is paperwork. The traditional grease and grime are rapidly fading from the profession. Engineers are being restyled into white collar office workers. The change can be ascribed to modern specialization, to decentralization of industry, and to the sprawling expansion of plants. Engineering design departments today are often located in another building, or even in another city, from that of the manufacturing plant. Paper bridges the gap.

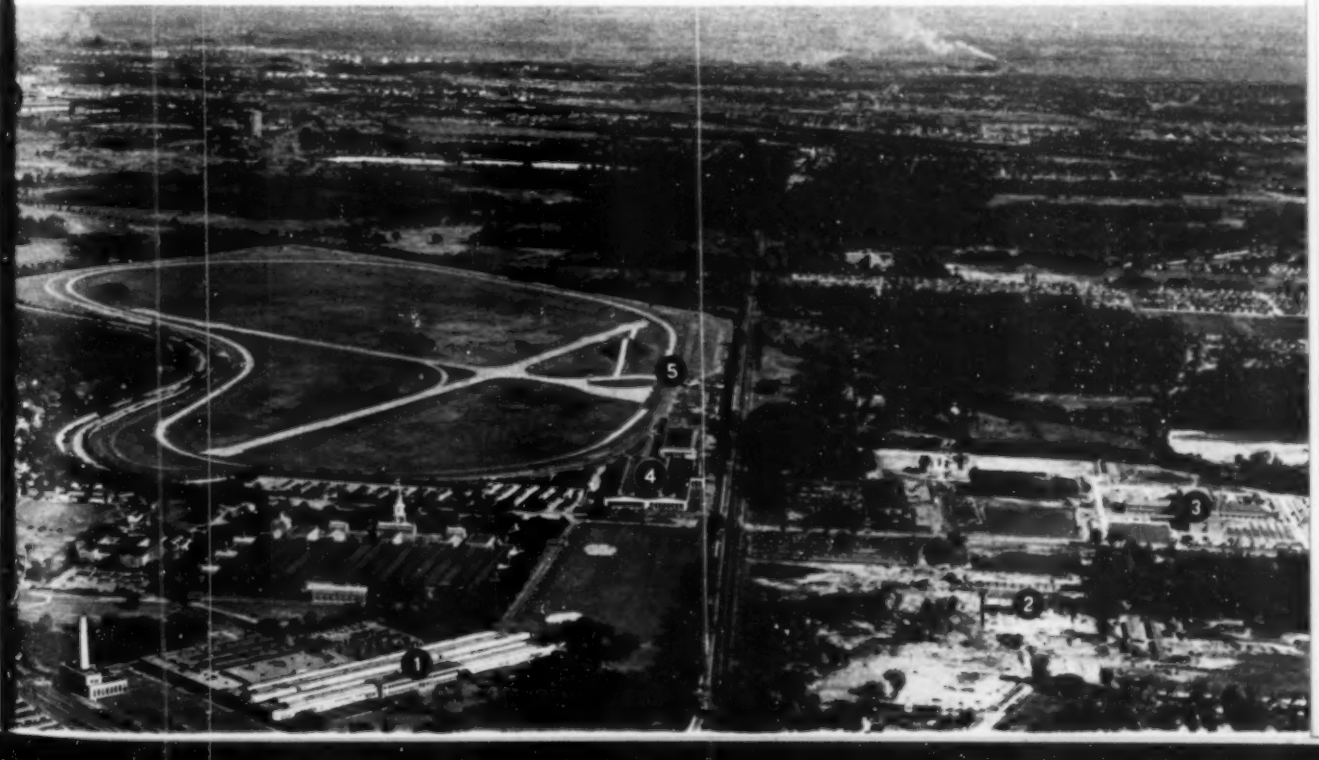
Today, the problems of engineering are complex; the field of design includes dozens of branches. In automotive design for example, the echelon of engineering specialists comprises: Body engineers, engine engineers, chassis engineers, electrical engineers, experimental engineers, test or transmission engineers. Supporting them are a host of others concerned with specifications, standards, administration, production, research, electronics, metallurgy, chemistry, and thermodynamics.

The pipe line from this vast reservoir of scientific and engineering know-how into production is choked with paper. From sales, service, purchasing, accounting, inspection, tooling, manufacturing, and customer research streams of paper engulf engineering executives. It's time someone put up the storm warnings.

In the automotive industry a new design's trip to production wriggles through this maze of paper:

1. Initial order from management to begin design work, make and test prototypes;
2. Release of experimental design

**Paperwork coordinates widely separated company activities. Typical of the spread of modern industry is the Engineering Center of Ford Motor Company: (1) Main engineering building; (2) New engineering building B foundations; (3) Research and dynamometer building; (4) Body engineering building; (5) Test area offices; and (6) Rouge assembly plant.**



information to the experimental shop;

3. Release of preliminary design information and preparation of preliminary parts lists;

4. Processing requests for design revisions from manufacturing, tooling, experimental and test engineers;

5. Release of production drawings and engineering information;

6. Preparation of production parts lists;

7. Processing requests for design changes and manufacturing deviations;

8. Approval of sample parts;

9. Releases and parts lists for customer options and factory installed accessories.

A natural assumption from this procedure might be that engineers revel in paperwork. Instead most enginers are irritated and hampered by it. The engineer's training and talents are aimed toward physical targets – the designing and producing of material things. Excessive paperwork goes against the grain. He is an unusual creative engineer who is concerned with clerical and administrative detail. Result: Engineering procedures often are patchwork affairs.

This paradox is costly. The paperwork that consumes so much engineering time and effort receives scant consideration or organized effort for improvement. The function of engineering procedures is comparable to that of the conveyor system in an assembly line. They should transport design information to the right spot at the right time.

Haphazard treatment of paperwork costs industry millions of dollars in needless waste every year. The evidence is as close as the nearest file cabinet. Offices everywhere are jammed with files stuffed with useless information. Antiquated methods and outmoded practices hamstring and frustrate employees.

Much can be done toward making the handling of paper more efficient.

A study in one firm resulted in eliminating 1500 out of 3000 forms. The study revealed that many of the forms were no longer necessary or that they merely duplicated information found in other records. Some had continued in use for years from sheer inertia. A redesign of many forms cut typing costs substantially.

The same firm devised an easy system to control work flow. At the end of the day, personnel are requested to list the jobs still hanging fire. As a result, potential bottlenecks are pinpointed and dealt with before they become serious.

**Main drafting room at Ford Engineering is the largest under one roof in the world.**

Through the redesign of an invoice form, a steel company increased production at a typing station by 71 percent, with a corresponding drop in eyestrain, fatigue and errors. By preprinting certain items, by doing away with skip spacing, by using tab stops to best advantage, and by using one vertical margin to avoid indentation spacing after a carriage return it was possible to save a total of 241 keystrokes and 10 carriage returns.

Where methods and procedures analysis are introduced, engineering departments are rewarded with a marked improvement in clerical efficiency. In one company, the engineering office learned from a detailed survey of all forms that fifty percent of them could be combined with others, or thrown out. Often the original use of a form had been forgotten.

A blueprint and tracing control problem that plagues many engineering departments is how to file and record thousands of drawings so that their status and location can be obtained instantaneously. One large aircraft manufacturer installed a new system, using swinging type visible control files, to solve this problem. The system operates as follows.

When a drawing is released by engineering, a four-copy Blueprint Distribution Sheet is prepared. One copy is held as a control record, one goes with the drawing as an order for blueprints, and the remaining two are sent to Blueprint Control and Tracing Control.

The Blueprint Control record, on the Visible Index, gives a rapid recap of the distribution of every blueprint. Often it is possible to pick up an extra needed copy, with a resultant saving in reproduction costs.

The visible index card, on which a single entry is typed, is made up and filed when Tracing Control receives the Blueprint Distribution Sheet. A yellow flag is slipped over the visible edge to show that the tracing is in the Blueprint Department. The flag comes off when the tracing is returned for filing. When drawing changes are ordered, tracings are withdrawn by a Charge Out Slip, which is a narrow slip of paper that can be filed behind its index card. These cards have the right corner trimmed off, so that either

Charge Out Slips or yellow flags are spotted at once when the file is opened. A drawing out of file can be located without delay.

Drawing change letters and dates are entered on the card from Blueprint Distribution Sheets. These entries provide an accurate record of the latest completed change on every drawing.

Mounted on desk stands, the swiveled frames permit instant access to 16,000 tracing records. A card can go in or out in little more than a second. Besides savings it made in clerical time and blueprinting costs, the new system reduced the number of lost or misplaced tracings.

Paperwork problems may involve forms, methods or procedures. Sometimes these problems are as obvious as a flat tire; others are as difficult to spot as a flaw in a casting. Clerks and even their supervisors often are too close to details of the work to recognize difficulties. Many people are content to carry on in the good old way of doing things, even if changing conditions have made their practices obsolete. Employees working on a job may lack knowledge and experience or be too busy to search out and install new methods.

A methods and procedures unit represents an objective viewpoint. It tackles the problem of modernizing and streamlining the chain of paper at the weak links.

Weak links are looked for where there are bottlenecks or delays; where forms are used in excessive quantities; where the variety of forms used is abnormal; and where the consumption of stationery supplies is excessive. An analytical study is called for when requests are made for new office machines, equipment, devices, or special office and filing supplies. An analysis is made when forms are to be reprinted, or where off and out-size records or forms are in use. Complicated procedures or procedures involving several groups are points where the analyst's help is required.

Once a problem is isolated the first step is to get all the facts. Operating personnel are interviewed. Questions asked are: What, Where, When, Who, How, and Why?

The most frequent and useful question is Why. Why is this form, operation, or procedure necessary? Why this method? In the search for facts, the analyst uses a sleuth's observation and logic to fill in the complete story.

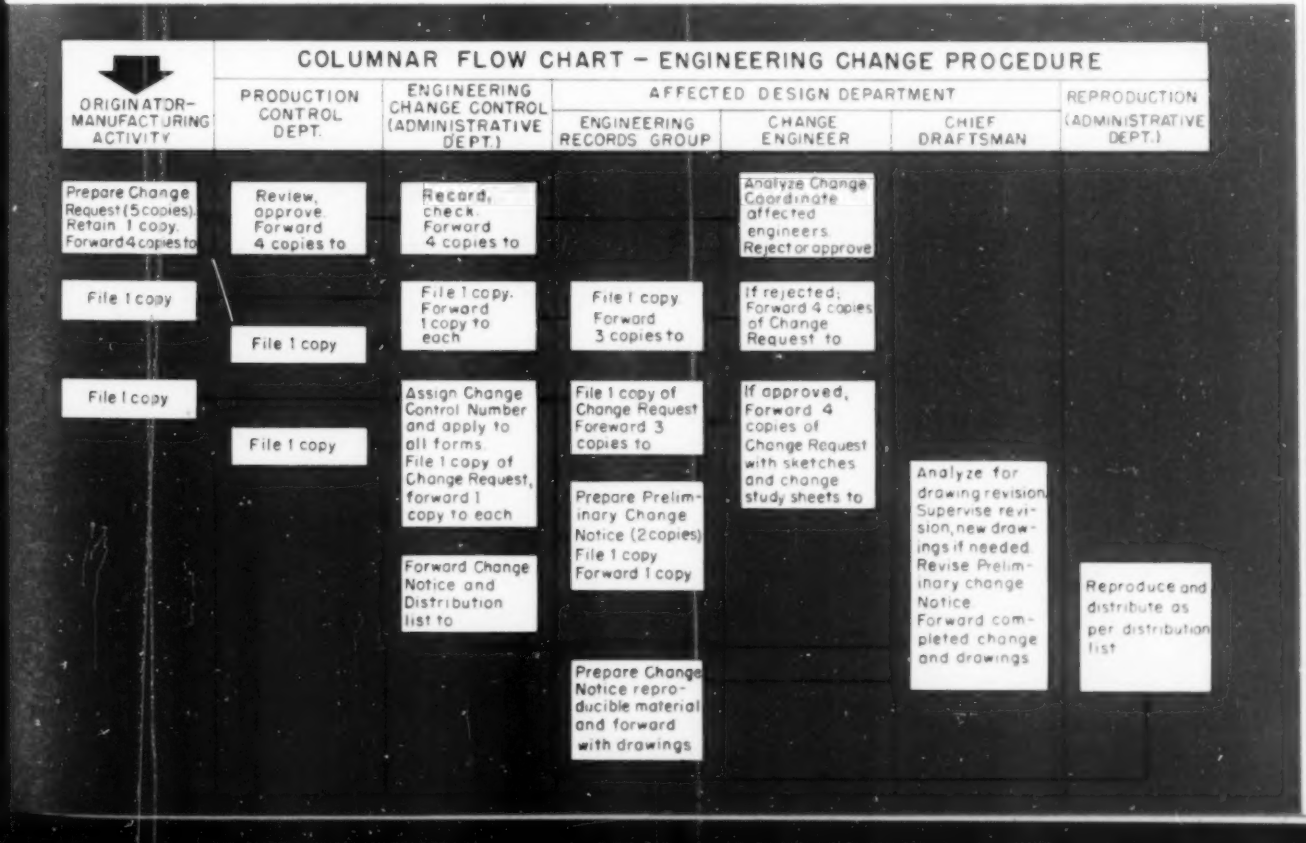
After the facts are collected, they are weighed and analyzed. At this stage a wide chasm often appears between the way people say a job is done and the way they actually do it. That is why facts must be dug, sorted and weighed carefully. But the main concern is: How should the job be done? Is there a simpler and better way?

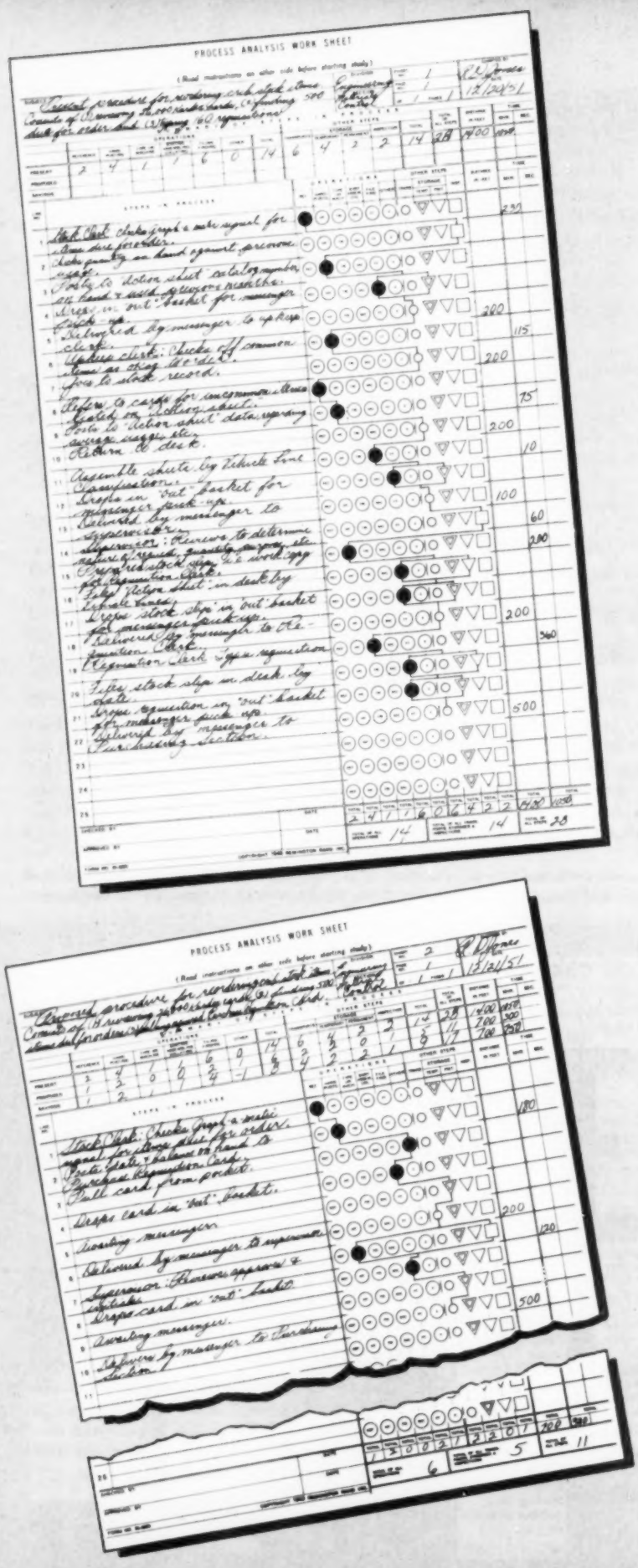
To discover the best and most practical method the analyst keeps certain objectives in focus at all times. These are to: Eliminate; combine; simplify; improve wherever possible. Can a form, step or entire operation be eliminated? If not, can it be combined with another? If not, can it be simplified or at least improved?

One fruitful field for betterment is the weeding out of extra copies. Apparently the belief is common that an extra copy or two can be distributed for no additional cost. "Send one to the boss so he knows what we're doing – and Bill Jones might like a copy too."

This impression is at the root of much excess paperwork. Such copies obviously take up the time of the clerical personnel who deliver, sort, and finally file them . . . as well as an executive's expensive handling time. A surprising number of copies of

**A simple columnar flow chart that clarifies procedure far more than do pages of detailed explanation; in addition, it saves the time of the engineering personnel concerned, and supplies directions to the new or inexperienced employees.**


COLUMNAR FLOW CHART – ENGINEERING CHANGE PROCEDURE
ORIGINATOR-MANUFACTURING ACTIVITY
PRODUCTION CONTROL DEPT.
ENGINEERING CHANGE CONTROL (ADMINISTRATIVE DEPT.)
AFFECTED DESIGN DEPARTMENT
ENGINEERING RECORDS GROUP
CHANGE ENGINEER
CHIEF DRAFTSMAN
REPRODUCTION (ADMINISTRATIVE DEPT.)
Prepare Change Request (5 copies). Retain 1 copy. Forward 4 copies to
Review, approve. Forward 4 copies to
Record, check. Forward 4 copies to
Analyze Change. Coordinate affected engineers. Reject or approve
File 1 copy
File 1 copy. Forward 1 copy to each
File 1 copy. Forward 3 copies to
If rejected; Forward 4 copies of Change Request to
File 1 copy
File 1 copy
Assign Change Control Number and apply to all forms. File 1 copy of Change Request, forward 1 copy to each
File 1 copy of Change Request Foreward 3 copies to
If approved, Forward 4 copies of Change Request with sketches and change study sheets to
Prepare Preliminary Change Notice (2 copies) File 1 copy Forward 1 copy
Analyze for drawing revision. Supervise revision, new drawings if needed. Revise Preliminary change Notice. Forward completed change and drawings
Reproduce and distribute as per distribution list
Forward Change Notice and Distribution list to
Prepare Change Notice reproducible material and forward with drawings




**The Process Analysis Work Sheet is a handy tool when streamlining a department's paper handling. This typical "before and after" example clearly demonstrates how profitably the industrial engineer's methods can be applied to paperwork when facts are analyzed.**

Remington Rand, Inc.

forms can be eliminated by a simple poll asking, "Do you use the copy you receive of this form?"

One major tool that cuts paperwork is the methods survey. This survey includes an inventory of all forms, reports and equipment used by a department or group and a study of its functions and paper operations. To collect necessary basic data for this type of analysis, a statement of duties report is requested of each employee of the group.

The methods survey develops specific recommendations for better utilization of basic elements in the office: Forms, reports, communications, equipment, machines, filing systems, space, procedures and personnel.

Such a survey of an engineering records group might result in the recommendation for preparation of parts lists by punched card equipment. Advantages cited for the new system are: Elimination of the retyping of numerous parts lists (or bills of materials); parts list can be prepared in a central location by a small number of clerks; and a single punch card contains all necessary information about each part or assembly. Mechanical sorting, collating and printing speeds production of the finished parts list. This list is maintained up-to-date at all times because revisions require only replacing, adding or subtracting a few cards rather than remaking the entire list. Before installing the new system, of course, a study should be made of the costs of new equipment, of securing and training personnel and of other factors.

Another basic approach to paperwork problems is through procedures analysis supplemented by forms control. Written procedures are almost indispensable in modern engineering, because they are so vital to translating a product design into actual production. They are the concern of virtually all engineering personnel.

The release of engineering information is probably the most impor-

tant administrative function. How can numerical requirements for models, next assembly, effective point for the drawing, material or stock information best be issued? To develop the best possible solution for any given set of circumstances requires scientific study.

Procedures analysis eliminates duplications, inconsistencies, and superfluous records of paperwork. It supplies missing links and the cure for ineffective controls. Too frequently clerical personnel are struggling in the dark without a roadmap of objectives. Published procedures can supply directions to swelling ranks of inexperienced clerical workers, upon whom engineering departments are being forced to rely more and more for the performance of the semi-technical jobs as the shortage of trained engineers grows.

A written procedure need not be long or involved. One form well adapted to engineering is the statement-outline, the various sections of which present the following:

Section I. List of forms used in the procedure identified by name and number.

Section II. Definitions of peculiar or ambiguous terms.

Section III. Statements covering policies and principles that apply to the procedure.

Section IV. Details of the procedure giving duties of operating groups according to the work flow sequence. In this section illustrations of properly completed forms are presented.

Section V. Flow Charts of the procedure depicting graphically the work flow outlined in the previous section.

To expect methods and procedures analysis to dissipate engineering's tidal wave of paper, is probably too optimistic. Some of the modern tools and techniques for cutting paperwork, nevertheless, can channel the flow of paper more effectively toward productive results and harness its potential for destruction and confusion.

Frequently the efficiency of many companies, even those who pride themselves on progressive policies, can be improved by unburdening themselves of the dead weight of muddled procedures that result from the lack of continuous control of their paperwork.

DUTIES STATEMENT

NAME _____ DATE _____

DEPT. _____ JOB CLASSIFICATION _____

UNIT _____ SUPERVISOR _____

| NO. OF ITEM | LIST OF DUTIES (DESCRIBE BRIEFLY TASKS PERFORMED DAILY, WEEKLY, OTHER BREAKING DOWN TO TENTHS OF AN HOUR. NUMBER EACH ONE.) | HOURS PER (STATE FOR ONE DAY, WEEK, MONTH) |
|---|---|---|
| | | |

TOTAL HOURS PER WEEK

FORMS USED

| FORM NO. | NAME OF FORM | PURPOSE USED FOR | FREQUENCY | QUANTITY |
|---|---|---|---|---|
| | | | | |

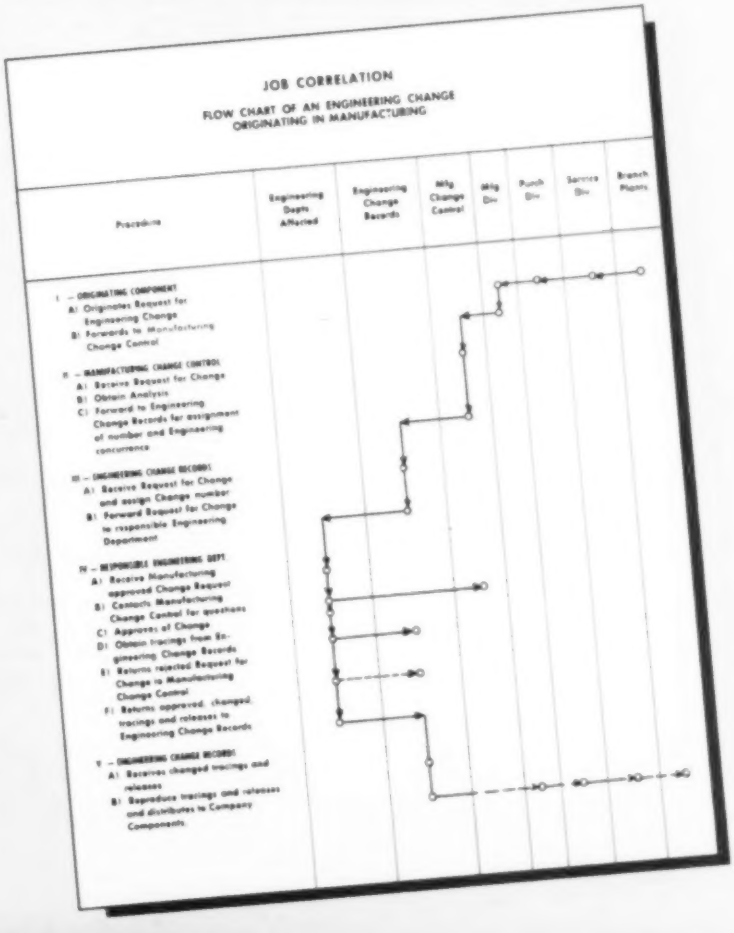
EQUIPMENT USED

| TYPE | DESCRIPTION (MAKE, KIND, ETC.) | PURPOSE USED FOR | FREQUENCY | TIME |
|---|---|---|---|---|
| | | | | |

(USE EXTRA SHEETS IF NEEDED)

**Statement of Duties form used to collect basic data in a methods survey. Each employee in the group is required to list in his statement all forms, reports and equipment used by him in the performance of his duties.**

**A correlation type flow chart, which depicts graphically the work flow, facilitates making an analysis for improvement of an existing system.**



JOB CORRELATION

FLOW CHART OF AN ENGINEERING CHANGE ORIGINATING IN MANUFACTURING

| Procedure | Engineering Depts Affected | Engineering Change Records | Mfg Change Control | Mfg Div | Punch Div | Service Div | Branch Plants |
|---|---|---|---|---|---|---|---|

I — ORIGINATING COMPONENT
A) Originates Request for Engineering Change
B) Forwards to Manufacturing Change Control

II — MANUFACTURING CHANGE CONTROL
A) Receive Request for Change
B) Obtain Analysis
C) Forward to Engineering Change Records for assignment of number and Engineering concurrence

III — ENGINEERING CHANGE RECORDS
A) Receive Request for Change and assign Change number
B) Forward Request for Change to responsible Engineering Department

IV — RESPONSIBLE ENGINEERING DEPT.
A) Receive Manufacturing approved Change Request
B) Contacts Manufacturing Change Control for questions
C) Approves of Change
D) Obtain tracings from Engineering Change Records
E) Returns rejected Request for Change to Manufacturing Change Control
F) Returns approved, changed tracings and releases to Engineering Change Records

V — ENGINEERING CHANGE RECORDS
A) Receives changed tracings and releases
B) Reproduces tracings and releases and distributes to Company Components

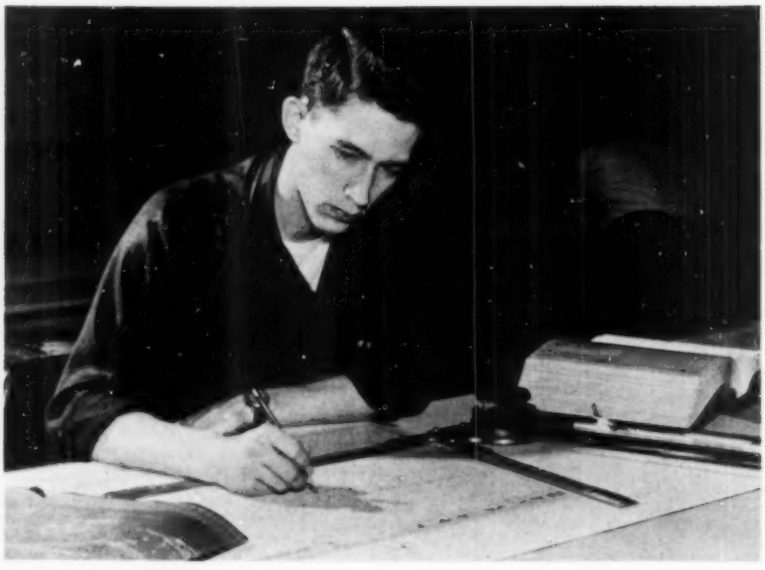


**Fig. 1 – Draftsman making a drawing on glass cloth, which is a dimensionally stable material. In a following step, photo templates of the drawing are made by contact printing on anodized dural. These photo templates are used as form block and router templates. Such drawings permit early production of parts.**

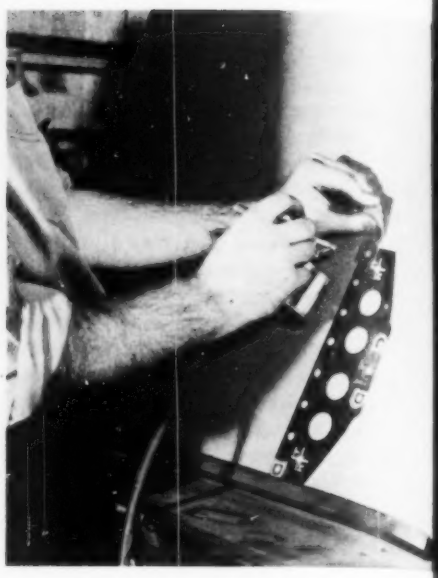


**Fig. 2 – To identify hole sizes, color coding is being added to a router drill template. This template has been sawed from a large photo template.**

# Engineering Foresight That Aids Production

**FRED P. LAUDAN**, Vice President of Manufacturing, Boeing Airplane Company

*How engineers can reduce overall cost of product by a knowledge of the many small problems that are inherent in the efficient operation of the production department.*

IN ADDITION to visualizing the procedures and operations associated with direct manufacture, engineers can do much to promote production economies by giving equal consideration to the organization involved with the planning, tooling, procuring and inspecting of the parts they design.

Engineering information and drawings affect many complex operations that lead up to or follow manufacture. The arrangement and content of a drawing, consequently, is of importance to far more than the production departments.

Parts should always be designed for the most economical method of manufacture whether the part is to be subcontracted for or made in the home plant.

In operating any plant efficiently, large problems are always present that must be met squarely and solved in one way or another. Of more importance, however, are the countless small problems that are too often ignored because none is backbreaking in itself. Like ants and termites, however, they keep persistently eating away at organizational efficiency.

To promote efficient production, engineers must recognize that no two parts are ever produced exactly identical. Cutting edges of tools wear during each cut, with the result that the edge not only varies between parts but progressively along the cut. Punches and dies wear and deform with resulting variation of parts. Material varies within tolerance limits in thickness, hardness, and composition. Tolerances, therefore, should be carefully considered before they are specified on the drawings. Dimensions of parts should not be held to unnecessarily close limits simply because it is physically possible to do so.

Tolerances in squareness, flatness, concentricity and similar variables should be indicated on drawings. Fit up of parts should be carefully considered; it must be remembered that extrusions, plate, bar and similar shapes are not received from the mill exactly flat, round or straight. When the design does not recognize these commercial tolerances, costly operations are necessary to refine such materials to closer limits.

Clearances should always be provided to allow for the cumulative effect of tolerances.

Access for equipment installation, inspection and adjustment is essential to economical production and should be carefully planned and provided.

Access for tools is another important factor that affects shop productibility. This item should be given primary consideration while design-

ing an airplane. Rivet bucking and driving is a particular operation in point. Free access for bucking of all rivets is tremendously important. Large diameter rivets should be called for only where good access is provided. In addition to the cost of driving heavy rivets with poor access, there is the danger of damaging costly parts in the attempt.

Selection of fasteners is a phase of design that has an extreme effect upon manufacturing economy. Each fastener has inherent characteristic virtues that make it particularly adaptable to given circumstances. Bolts, nuts, nut plates, screws, rivets, hi-shear rivets, lockbolts, blind lockbolts, and blind rivets are all available in various strengths, head styles, materials, finishes, and sizes. Their proper use, as contrasted with inappropriate applications, results in substantial savings.

When designing an assembly, it is usually desirable to standardize as much as possible on the assembly processes. Transportation from one facility to another often takes more time and costs more than does the actual manufacturing operation. If an article requires some rivets, it is usually better to do all riveting rather than to combine spotwelding with riveting. If it is to be spotwelded, avoid any but necessary stop rivets. Try to visualize the operations including transportation as well as the sequence of operations. Spotwelding must be done before any other assembly operation or installation of parts such as bushings and nut plates because of the cleaning acids that must be used prior to spotwelding. Thus, a design consisting of a mixture of rivets and spotwelds requires careful planning of sequencing and usually should be avoided.

Design for sealing can be such as to make manufacturing either easy or difficult. Not many years ago only boat bottoms of aircraft had to be sealed. The fuel tanks were welded. Other components just generally leaked air and rain. The cockpit enclosure or windshield that didn't leak was the exception. Now the entire aircraft must be sealed against air pressure from the inside and rain from the outside. Other gases and liquids that must be sealed in are high pressure high temperature air, water, alcohol, gasoline, kerosene, jet fuel, fuel vapors, flame, and fuming red nitric acid.

A recent innovation is the issuance by engineering of isometric drawings, Fig. 3, of the structure of sealed areas. On these the location of sealing compounds is shown by code markings. This procedure demands pre-consideration of the sealing problems in the design stage thus avoiding many production problems. It also requires production and tool planning in consideration of areas that are sealed during assembly.

In pressure areas, it is necessary only to seal joints and seams. In the construction shown in Fig. 3 (A), the injection seals will not make a continuous seal along the seam across hollow portion of stiffener. In fuel areas, the problem is more difficult because the fasteners must be sealed and the inside of the stiffener is inaccessible.

Sketches, notes and illustrations on drawings to assist in understanding complicated shapes and assemblies are invaluable to the production departments. If a certain sequence of assembly is important and has been planned in the design, if the designer has provided certain access that will be closed off by subsequent installation, then these items should be indicated by free hand sketches and notes. Many hours and errors can be saved in tooling and manufacturing when such information is given.

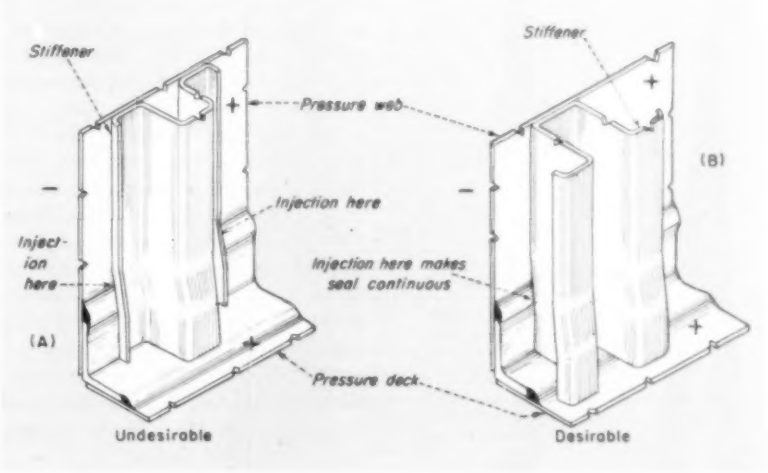
Glass cloth and metal drawings, which have been developed to such a high degree at Boeing, are ideally suited to economical tooling, production and inspection of parts that require from one to several templates. Such drawings permit production of parts much sooner after drawing release than do dimensioned paper drawings.

When paper drawings are released, highly skilled layout men must work day after day laying out the engineering information on metal. With glass cloth and metal drawings, duplicate layout is accomplished quickly and accurately by photographic means. Since only a small percent of the parts in an airplane do not require templates for production, it is obvious that resultant savings are large. Even for the so called "hot jobs," the manufacturing department still prefers glass cloth and metal drawings because of the savings of calendar time over any other method.

Standardization within a given model and between different models certainly promotes production economies, therefore, efforts should be made to ascertain by careful study what parts and accessories can be identical between various models. Where many identical parts are used in two, three or even four different models, the saving in cost and effort in procuring these items is substantial. Every reasonable design effort should be made to use standard hardware parts. Aside from the cost and effort of procuring many unlike parts, consider the cost and effort consumed in receiving, inspection, stocking, shop-delivering and inventory-control after the parts reach the plant. Add to these costs the chances for inaccurate call-outs that result in accumulating a supply of parts in stores that may never be needed. The assembly line of course, will stop for lack of some part that never was ordered, or if ordered is unavailable because of tight market conditions.

Most of this discussion has been concerned with "tremendous trifles" but they are the considerations that make either for smooth and efficient operation or for an inefficient, stumbling "start and stop" production line.

**Fig. 3 – Isometric drawing issued by engineering to show undesirable and desirable method of sealing seams in a structural assembly.**



# Matching the Job and the Man

*The Engineers' Society of Milwaukee conducted a survey among its engineer employee and employer members to determine their non-technical interests. From this survey came the Milwaukee Plan of Aptitude Testing discussed in this article. The Plan, still a professional research project, was set up to develop a comprehensive job specification system for virtually all engineering jobs, and to establish an effective means for specifying the aptitudes, interests and abilities of those engaged in engineering work.*

**ERHARDT C. KOERPER,** A. O. Smith Corporation

THE BROAD SUBJECTS of job description and personal characteristics of technical men are more often than not treated separately rather than jointly as they should be. Both are involved in the best compromise for matching a developing individual to a series of jobs, and it is the proper balance between the man and his job that contributes largely to the success of dynamic organizations. This article deals with a basic job specification system and shows how it can be used to define various jobs, their inherent responsibilities and interrelationships. Though this treatment is focused in its approach, it is based on considerations in the description of both individuals and jobs.

### *Advantages of a Descriptive System*

A job specification system is neither a simple listing of functions and time spent thereon, nor a rigid organization chart limiting the occupants functionally or psychologically. A good system should be part of a management philosophy to encourage and implement its policies and objectives, because it helps to keep the jobs in a growing framework of effectiveness. In such a framework, the system (1) permits a description of and a comparison between technical jobs, (2) shows organizational relationships as well as personal requirements, (3) defines the job in the same terms as those used for describing the man, (4) encourages counseling and supervisory evaluations, (5) facilitates direct evaluation and statistical treatment, and (6) helps in recruiting and training analysis.

### *The Milwaukee Plan*

The prerequisites of the Milwaukee Plan specified that it be workable on a practical level; broadly applicable to virtually all types of technical employees and their administrators; that all basic ideas should be agreeable to the psychologist, engineering educator, industrial executive and the professional engineer; and that the broad terminology in all phases of the Plan be standardized and readily understood by all concerned.

### *Job Specification Form*

The Job Specification Form used in the Milwaukee Plan is a simple three-page questionnaire-summary that can, if desired, be further condensed or put on punch cards. The first two pages, Fig. 1, encompass the organizational relationships and areas of responsibility, while the third page summarizes the personal requirements of the job. Though exceptions will be encountered, virtually all technical jobs can be sufficiently described by this form for the six practical uses listed above.

The description in Fig. 1 starts with the obvious items – job title, department and approximate size of department involved. Under Item 5, there is an abbreviated summary description of the duties and products dealt with. Items 6 and 7 cover the general fields of activity and the nature of the work (to give perspective to the job description). Items 8 and 9 indicate general minimum educational and training requirements. Items 10, 11 and 12 cover the degree

and natufe of supervision received and given. Item 13 defines the nature and diversity of judgment required by showing five graded steps. Item 14 defines four graded steps of the responsibility imposed, and finally Item 15 shows four possible types of contacts made in the course of the job.

### *Basic Descriptive Areas*

The basis on which the job specifications, patterned interviews and personal evaluations of the Milwaukee Plan are built is described in three general areas. Greatly simplified, the interests, aptitudes, abilities and job requirements are (1) Preponderantly Technical Traits – those primarily acquired as a result of education or training, (2) Preponderantly Psychological Traits – those that make up "personality," and (3) Physical and Manual Abilities–those that pertain to appearance, bearing and manipulative skills. In selecting individual traits or factors in each of these areas, it is important that the number be kept reasonably small; that each be significant, determinable or measurable; and that each be graded in descriptive steps pertinent to both the job description and to the applicant for the job. The criterion for inclusion of each factor is its practical use by each "interested party."

Table II lists individual factors or traits as they apply in varying degrees to technical jobs. Each factor is described by five graded standards of aptitude or ability that are consistent with the general spread found between both individuals and the jobs under consideration.

Some of these factors warrant additional comment.

T-1 – Scientific and Engineering Knowledge. The field or fields should be indicated in the adjacent space or under Item 5 of Fig. 1. If more than one technical field is involved, the relative importance should be indicated. Additional detail can be shown.

T-3 – Plans, Diagrams and Codes. The type of work done should be specified in addition to checking the grade involved.

S-8–Self Reliance and Drive. From careful analysis of surveys, it is clear that this item is generally considered highly desirable by supervisors.[5] Because of this, great care must be exercised to show only the minimum requirements for the particular job.

S-14 – Professional Aims and Development. Though these items are highly desirable in an individual, they might not actually be prerequisites for the job. Only the items applicable to the job should be checked.

M-16–Manual Abilities and Skills. This ranges over an enormous field, especially if technicians' jobs are to be included. The definitions of "simple" and "fine" tools depend on the organization making the definitions. Another tool description might include such categories as hand tools, machine tools or the preparation of various specimens or work pieces.

### *Job Descriptions for Counselor Use*

To show students and counselors the relative importance of these personal factors in the more common "pure" functions of engineering, the outline in Table I has been used as a guide. Most engineering jobs include various combinations of these functions. The four classifications at the right in Table I do not illustrate particular jobs.

### *Job Titles*

Job comparison by title is generally misleading because in different com-

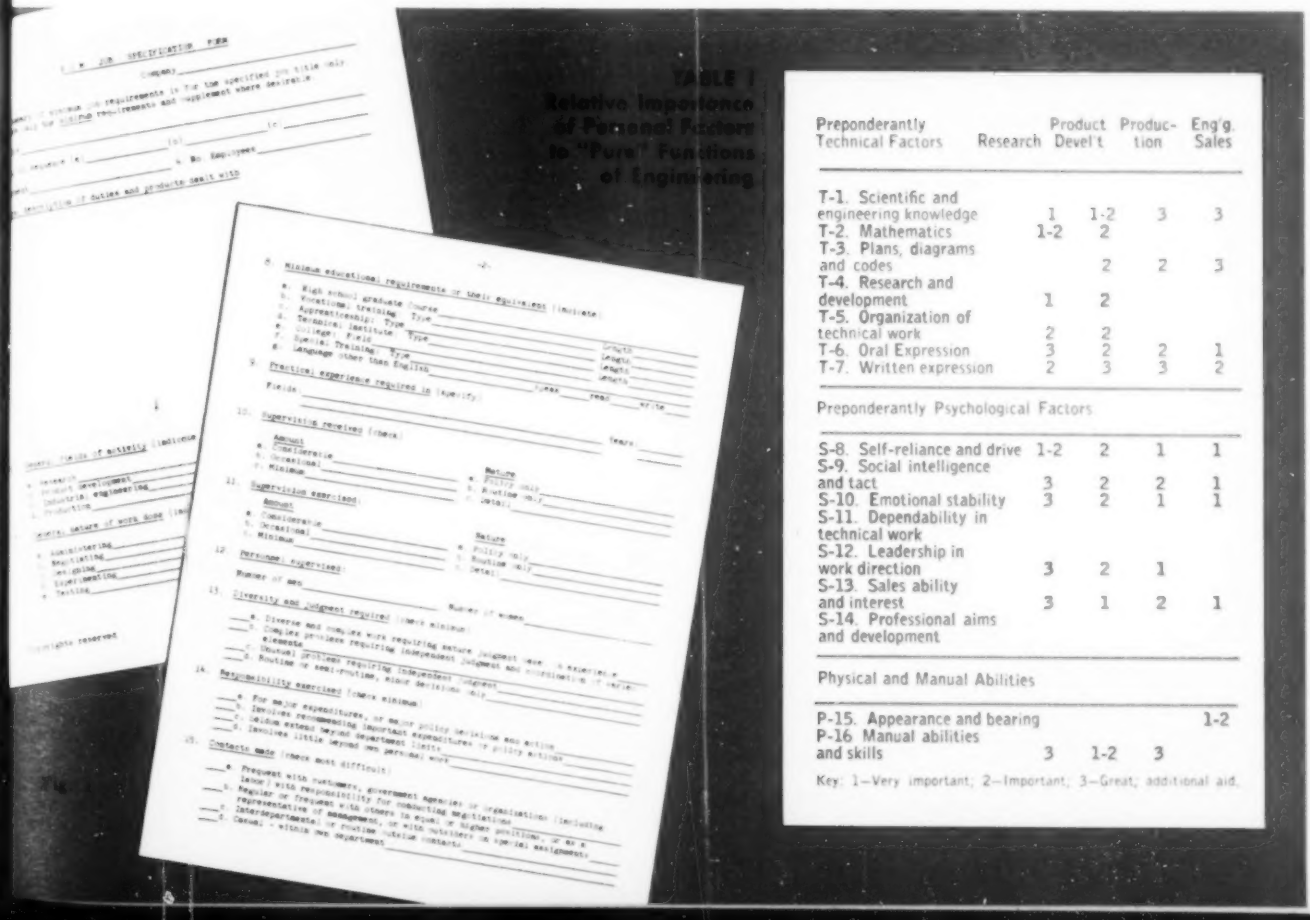


TABLE I
Relative Importance of Personal Factors to "Pure" Functions of Engineering

| Preponderantly Technical Factors | Research | Product Devel't | Production | Eng'g. Sales |
|---|---|---|---|---|
| T-1. Scientific and engineering knowledge | 1 | 1-2 | 3 | 3 |
| T-2. Mathematics | 1-2 | 2 | | |
| T-3. Plans, diagrams and codes | | 2 | 2 | 3 |
| T-4. Research and development | 1 | 2 | | |
| T-5. Organization of technical work | 2 | 2 | | |
| T-6. Oral Expression | 3 | 2 | 2 | 1 |
| T-7. Written expression | 2 | 3 | 3 | 2 |
| **Preponderantly Psychological Factors** | | | | |
| S-8. Self-reliance and drive | 1-2 | 2 | 1 | 1 |
| S-9. Social intelligence and tact | 3 | 2 | 2 | 1 |
| S-10. Emotional stability | 3 | 2 | 1 | 1 |
| S-11. Dependability in technical work | | | | |
| S-12. Leadership in work direction | 3 | 2 | 1 | |
| S-13. Sales ability and interest | 3 | 1 | 2 | 1 |
| S-14. Professional aims and development | | | | |
| **Physical and Manual Abilities** | | | | |
| P-15. Appearance and bearing | | | | 1-2 |
| P-16. Manual abilities and skills | 3 | 1-2 | 3 | |

Key: 1–Very important; 2–Important; 3–Great; additional aid.

## TABLE II — Gradation of Technical Traits Within Three Basic Descriptive Areas

### PREPONDERANTLY TECHNICAL FACTORS

**T-1. Scientific and Engineering Knowledge** – The job requires:
A. Carrying through a long series of varied complex analyses involving a number of technical fields. Indicate fields:
B. Carrying through complex analyses in one specific field.
C. Carrying through simple analyses in one specific field, independently.
D. Carrying through simple analyses in one specific field with some technical assistance and guidance.
E. Interpreting only simple technical facts under close supervision.

**T-2. Mathematics** – The job requires:
A. Developing complex mathematical formulae from observed and deduced data.
B. Applying calculus and higher mathematics to assigned problems.
C. Applying college algebra, analytical geometry, trigonometry and logarithms.
D. Applying high school algebra, geometry, trigonometry and logarithms.
E. Using arithmetic, percentages, fractions, etc.

**T-3. Plans, Drawings, Diagrams and Codes** – The job requires:
A. Preparing complicated plans, diagrams or codes.
B. Preparing a variety of simple plans, diagrams or codes.
C. Interpreting simple plans, diagrams or codes for action of others.
D. Understanding simple plans, diagrams or codes.
E. Little or no knowledge of engineering plans, diagrams or codes.

**T-4. Research and Development** – The job requires:
A. Developing numerous ideas, techniques, and new sources of information for the original solutions of new applications in various fields.
B. Establishing experimental procedures in developing new relations and applications in a specific field.
C. Associating new ideas and developments with new technical problems.
D. Using only past experience in meeting new technical problems.
E. Little or no research ability.

**T-5. Organization of Technical Work** – The job requires planning and organizing of:
A. Complex work assignments for numerous interrelated groups.
B. Work for numerous unrelated individuals.
C. Work for a small single group of individuals.
D. Varied technical work for own execution.
E. None required; routine work only.

**T-6. Clarity of Expression in Speech** – The job requires:
A. Preparing and presenting highly technical subjects clearly and conclusively for critical audience.
B. Presenting complex ideas clearly and conclusively in reports or conference.
C. Speaking extemporaneously and convincingly about simple ideas and things in every day contacts with customers, associates, etc.
D. Conveying instructions clearly to others.
E. Meeting only normal conversational requirements.

**T-7. Clarity of Expression in Writing** – The job requires the writing of:
A. Highly technical material for interesting reading.
B. Comprehensive reports with sound conclusions for basis of action.
C. Technical correspondence with sales representatives, customers, etc.
D. Informal memoranda and routine reports.
E. Job does not require writing abilities.

### PREPONDERANTLY PSYCHOLOGICAL FACTORS

**S-8. Self-reliance and Drive** – The job requires:
A. Initiating and following through simultaneously multiple complex problems with dispatch.
B. Initiating and carrying through unrelated complex projects.
C. Following through single complex projects.
D. Following through simple projects unaided.
E. Following through simple projects with assistance.

**S-9. Social Intelligence and Tact** – The job requires:
A. Recognizing and reconciling divergent view points in a group working under difficult circumstances.
B. Ability to maintain good personality relationship in everyday job relations.
C. Recognizing social relationships and problems between oneself and other individuals.
D. Recognizing social relationships and reconciling social situations between two other individuals.
E. Little personal contact–almost no skill required.

**S-10. Emotional Stability** – The job requires:
A. Great stability – in addition requires the ability to maintain and encourage stability in others.
B. Great stability in coping with emotional stress involved under pressure of work.
C. Stability when under more than usual pressure to expedite work.
D. Stability when under occasional heavy demands in work load.
E. Stability in routine work with little or no personal stress involved.

**S-11. Dependability in Scientific and Engineering Work** – The job requires thoroughness and accuracy on:
A. All work submitted or supervised including that of complex relations in new technical areas.
B. Complex analyses and calculations in relatively familiar field.
C. Simple analyses and results.
D. Simple formulae and results.
E. No responsibility for accuracy.

**S-12. Leadership in Work Direction** – The job requires giving:
A. Inspiring leadership of groups on a variety of activities which is effective through two subordinate levels of supervision.
B. Inspiring leadership and coordination of simple activities which is effective through one subordinate level of supervision.
C. Direct leadership for small groups.
D. Leadership on occasions only when requested.
E. No leadership.

**S-13. Sales Ability and Interest** – The job requires ability to interest and convince:
A. Numerous people with varied interests about new ideas and things.
B. Small groups of people with varied interests about new ideas and things.
C. Individuals about ideas.
D. Individuals in things.
E. Does not require ability to influence people.

**S-14. Professional Aims and Development** – The job requires consistent interest in and:
A. Contributing time and effort to community and civic interests.
B. Contributing time and effort to advancing sciences or engineering profession.
C. Improving self culturally, in some subject, through a definite program.
D. Developing self technically for present or next job.
E. Devoting little or no effort to technical self-improvement.

### PHYSICAL AND MANUAL ABILITIES

**M-15. Appearance and Bearing** – The job requires:
A. Appearing confident and poised in difficult situations.
B. Ready acceptance by strangers for appearance and bearing.
C. Acceptance by associates in respect to appearances and bearing.
D. Appearance is not a factor.
E. Appearance not applicable.

**M-16. Manual Abilities and Skills** – The job requires:
A. Great manual skill with fine tools and equipment in conjunction with a good sense of proportion and creative imagination.
B. Good manual skill with fine tools and equipment with good sense of proportion.
C. Good manual skill with a variety of simple tools and equipment.
D. Fair skill with simple tools and equipment.
E. Little manual dexterity. (Indicate tools and type of equipment used:)

panies both the concept and actual job may be quite different. In one company, the title of Chief Engineer might carry responsibilities comparable to a Vice President; in another it might be those of Chief Designer. Similarly, a Sales Engineer's job in a radio component parts manufacturer would be quite different than that of a Sales Engineer for a capital goods manufacturer. Actually, job titles are not too important as long as the job content is known and generally treated in a consistent manner.

### *Growing Individuals*

Individuals in jobs should grow and develop for, unless they do, they are merely suited for routine work. In recognizing this development, it is desirable that cognizance be taken of particular areas or channels of development. To accomplish this, a clear understanding of job requirements and the natural sequence of jobs is invaluable.

An individual who can "just do" a particular job will be only mediocre in its performance because it already demands his utmost. Not until he can do more than the job demands will he be a success. It therefore follows that a man should be better than his job if he is to grow into another one. If job descriptions are in simple terms, he can compare his ability to the job requirements; he as well as his supervisor will be in better positions to recognize and overcome shortcomings and to take the greatest advantages of strong points. The use of personal job factors permits this and, if properly presented, will greatly encourage such comparison.

Most individuals working on technical jobs are inclined to be analytical about things that can be readily measured or determined. However, when it comes to animate things and especially themselves, yard-sticks and slide rules lose their significance. In these cases, the personal descriptive factors have great comparative value. For example, if a man can write only "informal memoranda and routine reports" (D under T-7) and the job requires the writing of "comprehensive reports with sound conclusions for basis of action" (B under T-7), it is obvious that a shortcoming is present. This common knowledge can be a challenge to both the man and his supervisor.

This type of analytical treatment is desired instead of the too-frequently-heard comments: "He's pretty good," or "He's not so hot." Generally, such comments are cover-ups for a poor fit of a man to a job or a poor understanding of the job requirements.

### *Use of the Specification Form*

Numerous supervisors in the development and engineering departments at eight of the larger technical industrial companies of Milwaukee cooperated in the development of the Plan. Few of these supervisors had previous detailed experience with personnel evaluations and job descriptions. Yet, it was their general experience that the use of common descriptive factors for both personnel and their jobs gave them a new perspective and understanding of both individuals and jobs. In some cases, this was gratefully recognized by the men supervised.

In addition to the use of the basic factors for student counseling, the Job Specification Form has been used by technical schools to analyze the job requirements in industry for which they have been preparing their students. This is of assistance to the teaching staff for curricular evaluation. The same information also gives the students a better understanding of the various jobs.

An interesting example in the use of the Job Specification Form followed a discussion with the head of a large Quality Control Section in one of the armed forces. The difficulty outlined was in adequately describing jobs in a long detailed written description; yet, to show less detail appeared to give insufficient information. In addition, engineers could not be interested in the type of jobs described at the salaries offered.

As a test, the detailed, single-spaced, five-page description of a "quality control engineer (electronics)" and the Job Specification Form were given to a quality control supervisor. Without instruction he was asked to transcribe the detailed description onto the Form. In 10 minutes the job was relatively complete and the supervisor reported "That's easy!"

In transcribing the description to the ESM Form, he found it possible to take only one paragraph verbatim and place it under Item 5, in Fig 1, "General Description of duties...". All of the other information readily adapted itself with checks or figures to the Form. Furthermore, the Form revealed the need for information that had not been covered in the very much longer description.

One of the conclusions coming out of this experience was that the job could be performed quite satisfactorily by a technician. The talents and knowledge of an engineer would be wasted on this job. It also became obvious from the Form that, while the original description was sufficient for placement, it was sadly lacking when it came to organizational requirements.

Rapidly moving organizations at times lose sight of the functional and psychological inter-relationship of the individuals on their jobs, and this condition is quickly sensed by those working in such an atmosphere. The resulting indifference is of critical importance, especially in the permormance of jobs not easily measured by the number of units produced per manpower of effort. Typical of these are jobs in engineering and research departments where standards of effort are difficult to establish. Because of the engineer's work is primarily intellectual and a matter of judgment, job satisfaction is based in great part on a current evaluation of performance against the requirements of the job.

Anything that encourages more continuing personal evaluation of the man on the job provides greater incentive and better performance. This, in turn, reflects itself in the more rapid development and the increased value of the individual. Sound job structures are essential to such continued relationships and, consequently, a sound job specification system has a psychological value as well as organizational benefits.

A good job specification system can also be used directly in counseling, training, recruiting and organizational analysis. In each case, such a system is not difficult to install, and its integrated use is important to both the organization and its personnel. It will pay continuing dividends in increased personal and organizational values if used in its various fields of application. The recognition and application of these fundamentals is clearly a function of management and supervision.

## WHAT JAMES F. LINCOLN SAYS ABOUT INCE

**Incentive management is a means of giving the opportunity and spur to the individual so that he will develop his latent abilities.**

★ ★ ★

**The development of a higher standard of living must be made by replacing the present skills and abilities by new ones that will make our present production methods out of date. This perhaps would seem impossible now to the unthinking. However, the newer and better methods will be obvious to us when we develop them. In industry, that is the incentive and virtue of the free competitive system which has been developed so greatly in America.**

★ ★ ★

**We now value liberty very little. We have developed a philosophy which shuns individual responsibility. Looking ahead is a lost art for many people. Many an American concludes that if he has a hot dog in his hand, a shot of liquor under his belt and a gallon of gas in his car, he is free from responsibility. If any of these things is missing, he feels that government should take steps to supply it. Perhaps this is a natural development of a prosperous people.**

★ ★ ★

**It is not necessary to check on a player in an amateur game to see if he tries. There is no doubt he will try. Likewise, in industry under incentive management, all try. Many overhead jobs, therefore, such as many foremen, inspectors and clerks are needless, since the desire to produce at top speed and accuracy is inherent in all involved – they do not need to be watched.**

★ ★ ★

**The threat of losing his job makes a worker keen to protect himself so that his job is secure; however, this security is obtained by developing his own perfection. This perfection, however, endangers the job of the less perfect worker, and so it must be if our economy is to grow. We may not like the threat, but we must meet it or progress stops, and with this lack of progress, the nation loses its place in the world. Then men go back to savagery and extinction. We either go forward or back. We can't stand still.**

★ ★ ★

**The proportion of workers in industry is continually increasing as efficiency of production increases. The only time when jobs disappear in industry is when progress is not made in efficiency so that progressively lower prices can be given to the consumer so he can buy a progressively higher standard of living.**

★ ★ ★

**His own security is an attainable reward for which any normal man can and must be responsible. If we try to make a gift or guarantee of the state, the normal incentive that all must have to grow will disappear. When that happens, the nation disappears with it, as all history so fully shows.**

★ ★ ★

**Russia has a system of incentive that is different. She rewards the efficient with better housing, better food, better facilities of all kinds.**

# Financial Incentives for En

*The production bonus system at the Lincoln Electric Company applies not only to the shop but to the engineering department as well.*
*The following recorded interview gives the reactions of George Landis, Vice President of Engineering, and L. K. Stringham, Chief Engineer, to the system.*

**PE** – Is money as big an incentive as many people believe? Is this incentive really effective in increasing the quality and the quantity of engineering output?

**Stringham** – If a man doesn't have enough money to do the things that he really should do, if he doesn't have enough money to properly clothe and feed his family, the most potent incentive he can find is money. But if he, for all practical purposes doesn't have any wants, then money as an incentive loses its effectiveness. For example, if we attempted to double the pay of every person here but took away the two week vacation period, I doubt that we could sell it.

**PE** – What are the mechanics of determining a man's merit rating?

**Stringham** – The actual mechanics of merit rating are difficult to describe since they are constantly changing.

**PE**–Well, how about the basic principles involved.

**Stringham** – The first thing to understand is where merit rating fits into the overall system of compensation. We have a base pay which is established by job evaluation or some other job potential rating system. To this is added the year end bonus. Merit rating is used in determining the relation of a person's base pay to his share in the total bonus. The total bonus for the company is determined by the success of the operation for the year and merit rating is used to measure a person's cooperative effort within

**Russia punishes the laggard by putting him in a prison camp in which he has less food and more interference with his personal freedom and perhaps death. There is no doubt as to the reality and direction of Russian incentive.**

★ ★ ★

**The one most important point to be remembered is that no one would ever have become a swimmer if he were not in water of sufficient depth to make swimming possible and perhaps necessary. If the problem had never been put to the individual he would never have solved it. He was a latent swimmer always. He became an actual swimmer only because of conditions that forced him to swim. Latent abilities are like clay – it can be mud on the shoes, brick in a building or a statue that will inspire all who see it. The clay is the same. The result is dependent on how it is used.**

★ ★ ★

**There is frequently the comment made by the thoughtless that high production, such as is usual with incentive management, must mean that the workers involved will wear themselves out in a short time. Union leadership continually harps on "sweating" the worker by the "speed-up" that they claim results from incentive. What is the relative length of life of a worker and a loafer? If work shortens life, then loafing must lengthen it. The facts show the direct opposite. How long does a worker live after retirement? How good is his health if he stops work and loafs? Ask any man who has had experience.**

★ ★ ★

**The greatest waste that can be imagined, far greater than any material waste, is the waste of man. Undeveloped man will always be a far greater loss to the economy than any material loss, no matter how serious that loss may be.**

★ ★ ★

**Incentive management is not a so-called efficiency scheme alone. It is a philosophy of life and production that develops new aspirations and usefulness in all affected by it. Do not approach it from any other point of view. Incentive is not a way to get the worker to do more as an end in itself. It is a way to get him to play the game in industry as a member of the economic team that has made America greater than any other nation, economically. Incentive also opens a way toward fuller realization of the American dream and the promise of a fuller, richer, happier, better life for all mankind.**

★ ★ ★

**Eventually, the strong and virile will replace the weak and lazy. The problem that we in America must solve is to make sure such replacement is done by us. If we do not, a more virile nation which has allowed natural competition to determine the winners and losers in the game of life and industry will take us over.**

★ ★ ★

***Mr. Lincoln's new book, *Incentive Management*, is available from The Lincoln Electric Company, Cleveland 17, Ohio – Price $1.00.**

# r Engineers

his department towards producing that bonus.

For merit rating, each person is rated against standards of job performance – not against a predetermined average performance. For example, he may be rated in efficiency either excellent, good, acceptable, fair or poor,, without regard to which one of these standards might turn out to be the average for the department.

Each person to be rated is assigned a set of cards on which is described briefly seven standards of job performance. There is a card for each merit rating factor. The standard which best describes the performance of the man being rated is checked by the person rating so that finally each person ends up with a set of cards marked according to his performance. By using a standard description of job performance against which actual performance is checked, we in effect rate each person in comparison with others doing similar work.

**PE** – Do you actually assign points to each individual?

**Landis** – After all ratings are made, the cards for a given department are lined up so that from the check marks an average for the group can be determined. Points are then assigned to all ratings according to where the average falls.

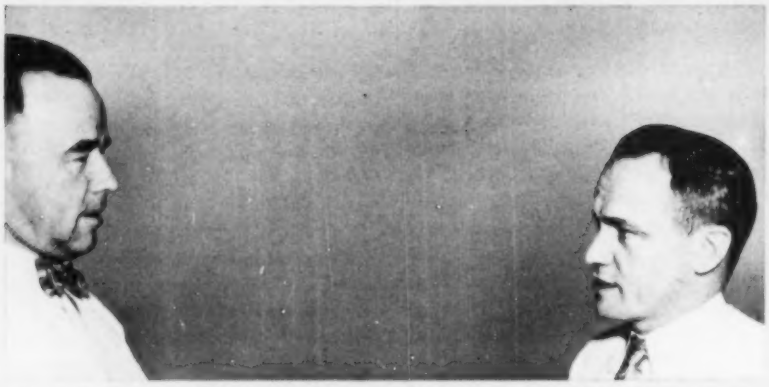
This system of rating without first assigning points permits the average for a department to "float" up or down as performance of the group improves or falls off. Thus a man could do the same job he did in the previous year and yet receive a lower rating because the performance level of his department has improved and the "average" performance is at a higher level. Similarly if the general level of performance of the whole company rises or falls, a person's individual bonus could rise or fall regardless of whether or not his merit rating was the same as previous years.

After rating points have been assigned for all factors, a final figure, the sum of all factors, is assigned to each man for his merit rating. This figure along with other recommendations for special consideration are sent to Mr. Lincoln for determining the bonus. The man with an average rating will receive an average bonus. Last year the total bonus divided was 104 per cent of the total payroll for the year.

**PE** – Suppose an engineer's job responsibility changes during the year, and until gaining the necessary experience, he is less proficient than in his old job.

**Landis** – He may get less money because of that fact, although eventually he will get more. It doesn't mean that he's going down hill. It simply means that he's playing for a long gain rather than for an immediate gain.

**PE** – Aren't the things that the engineering department does much



**(Landis) Amount of bonus is determined in part by a merit rating based on initiative, efficiency, and accuracy. From that rating, each man can find out his strong points and weaknesses. As a general rule, the causes of a low rating when spotted and explained are recognized by the man and he will try to correct them.**

**(Landis) If management impresses on a man that his work is important and his talents are needed, it has done much to create a satisfied employee.**

more intangible than the things that the production department does?

**Stringham** – If you accept the fact that you can set up salaries for people whose returns are intangible, and that's true of any professional man – if you accept the fact that you can set up a salary which is commensurate with the value of that man compared to the value of some man who is on piece work rates – then you have no further difficulty as far as merit rating is concerned.

It might interest you to know that each man knows what rating he has been given. He doesn't know what other people got, but he does know what he got, and he knows the average is 100 too. He knows that if he got a rating of 100 he did an average job. I don't say that's bad or good – he just did his job. He was adequate. If he got a rate higher than 100, that would indicate that he did more than was expected.

**PE** – Do any of your engineers ever come in and show any resentment?

**Landis** – Well, there are some who don't understand why they were rated as they were, and that's one of the reasons for the system. We hope that they will come in. We'd be disappointed if they didn't. Usually this results in some change, either in quality of work or, in some cases, better recognition of the requirements of their own job. It's very important from that standpoint. It isn't just a gripe that you salve over and make a man happy. That would be destroying the value of the system. A man comes in, and he says: "I don't understand why I got 78 per cent on my merit rating. Particularly, I don't see why you sent it home so my wife saw it." You tell him why, and in the course of that conversation you should find something that would be of value in getting that man to a point where he can get 100 per cent or more.

You might uncover something that shows he's on the wrong job. He may be doing something he's not fitted for at all, and he should be transferred. The point is that there should be some correction made, and if there is no correction made as a result of that complaint, then the system hasn't worked.

**PE** – What advantage is an incentive lump sum payment at the end of the year? What advantage does it have over a better salary in the course of 12 months?

**Landis** – Well, there are two things about it. One is that as a rule a lump sum means more to a man than an increase in salary. There are a lot of men around here who have bought homes, farms, or parts of businesses. They would never have found enough capital at one time to do it if they had gotten it as a monthly increase.

Furthermore, a large fluctuation in salary from year to year – based on profits – is impractical. I would hate to give a man a high salary this year, a medium salary next year and a low salary the next year or have his salary from year to year vary up and down. People normally have certain scales of living to maintain.

**Stringham** – It is an incentive for everybody to do everything he can to see that the profit of the company stays up, because he knows that if the profits drop, the bonus is going to drop too.

Finally, a company never can pay in salaries an amount equal to what it can pay in salaries and bonus. It cannot go through the agony of cutting salaries because profits go down.

**PE** – In other words, your margin here between total pay and profits is much narrower.

**Stringham** – We can pay outstanding men more nearly what we'd like to pay them without fear that there's going to be a bad effect due to a decreased payment next year. In '38, we had to cut the bonus down to about ½ or thereabouts of what we had in '37, and everybody understood it. Nobody was hurt by it, and there was no adverse comment on it. But if we had cut salaries down to ⅔ of the previous year, which might have been necessary, we'd have had something to live with. The average person can understand a cut in bonus.

**Landis** – And furthermore, he would have geared his living pretty close to his take-home pay. As it is, he can use a bonus for sizeable investments, a house or a farm, or maybe a better car. Maybe it otherwise would be dissipated in little

**(Stringham) When a man doesn't have enough money to do the things he should do, his most potent incentive is money – but it is not a panacea.**

**(Landis) If you can set up salary levels for employees whose contributions are intangible, you also can establish a bonus system covering them.**

**(Stringham) No company can afford to pay in salary what it can pay in salary plus bonus. There would be too much fluctuation in a man's pay.**

expenditures that would have no permanent value.

**PE** – Do you use any incentives other than money?

**Stringham** – Money cannot be used as the only incentive. It's good only up to a point. Let's say, however, that we believe it extremely important to recognize accomplishment.

There's one thing which Mr. Lincoln has done at bonus time that I know has some effect. At the time the bonus is delivered, he picks out several men who work directly for him, and points out that for that particular year they've done an outstanding job. Then each department will pick out a man and Mr. Lincoln will personally call that man up to give him his bonus check. Normally the big envelope is given to a department head and he passes out each check, but in these particular cases, there is special recognition for outstanding work.

**PE** – Do you also offer an engineer an incentive in terms of patent royalties?

**Landis** – No sir. Any patents which are taken out in an individual's name are turned over to the company. Engineers spend the company's money and they're paid to do it, so why should they have any patent royalty rights? Any patents which are taken out at the request of the company, are paid for by the company and become the property of the company for $1.00. To me that's the only logical thing to do.

**PE** – Do you give a man any kind of recognition after he's had, let's say 5 or 10 patents? Do you give him a pat on the back in any way?

**Landis** – Well, not for that, no. But that would show up in income and bonus, and of course it would show up in relative standing in the company.

**PE** – Do you offer him the opportunity to further his education in any way?

**Stringham** – There probably isn't a city in the country where that's easier to do than the city of Cleveland. He takes the initiative.

**PE** – You don't pay half of his tuition, or . . .

**Stringham** – No.

**PE** – Do you encourage it in any way?

**Landis** – No I wouldn't say we encourage it as such. We tell our people that to do a particular type of work, they must fulfill certain minimum educational requirements.

**PE** – How about society meetings and activities of that sort. Do you encourage membership in certain societies and ask that your engineers get to meetings?

**Stringham** – No. Any professional societies they belong to they belong to on their own. But I do point out that technical meetings provide an excellent opportunity to keep abreast of developments, to meet professional people, and by taking an active part in affairs, to learn how to get across an idea.

One shortcoming in an engineering education is that there is not enough emphasis placed on getting along with people.

**PE** – How can we sum up this question of financial incentives?

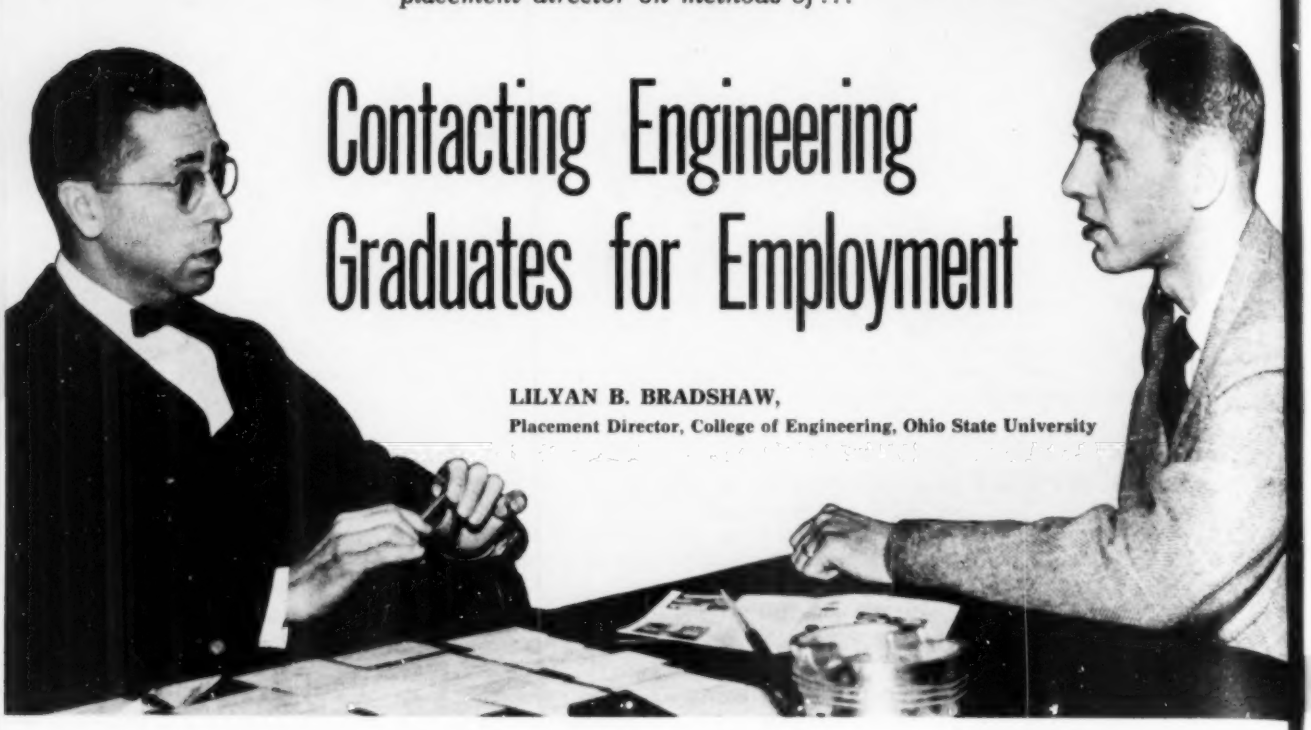
**Landis** – One of the biggest incentives – and I'm speaking about engineering primarily, although I think it applies generally – is for a man to know that the thing he is doing is important, that people would miss him in case he didn't come to work.

In order to do that properly in engineering, at least, it's necessary for the engineer to do a lot more than simply design the equipment. He must be given some responsibility for its performance. We make our engineers responsible for their equipment from design to operation. If trouble develops in the field, the project engineering must straighten it out. That way, he follows the equipment through the shop and actually sees how customers are using it.

But we do not forget that one of the most important forms of recognition of a job well done is money. In our case, incentive management has permitted us to build a better product, at lower cost, and to pay our employees on a much higher scale in direct proportion to their contributions to the welfare of the company.

*For the next several years the supply of engineering graduates will fall far short of requirements. Here is some practical advice from a college placement director on methods of...*

# Contacting Engineering Graduates for Employment



**LILYAN B. BRADSHAW,**
**Placement Director, College of Engineering, Ohio State University**

THE CHANCES ARE that the eager, mature looking, brief case clutching individual seen in large numbers on the campuses today is no longer a left over G.I. trying to catch up with a delayed education, but an industrial recruiter searching for technical and scientific personnel.

In a time when the competition for such men has reached an unprecedented high, personnel departments are confronted with a problem that keeps them up late at night trying to devise ways and means by which they can outsmart their competitors and win a favorable nod from the young graduates. Meanwhile, sitting comfortably secure on his pedestal of desirability, the embryonic scientist or engineer looks calmly down on the troubled crowd and realizes that in whichever direction he descends, opportunity awaits him.

Amazing as this situation is, it is predicted that it will continue for the next several years. One has only to study the enrollment figures of colleges and universities throughout the country to realize what effect the low birth rate of the depression thirties, coupled with the compulsion of military service, will have on the numbers of graduates who can possibly become available for employment.

For example, in 1950, approximately 52,000 engineering students were graduated; most of the G.I.'s finished that year. Shortly after, the Bureau of Labor Statistics put out a report that there was a glut of engineers, and this had an appreciable influence on high school counselors, who did not advise their students to major in engineering and science. In 1951, the number of graduates in these curricula dropped to 38,000 and the figure for 1952 was approximately 26,000. In 1953, the graduates will number 17,000; in 1954 the number will not be any greater. Industry's requirements are on the order of 30,000 annually, and by 1954, it is estimated that they will be nearer 36,000 engineers per year.

There are certain areas of engineering in which the need is greater than others. A really topnotch Mechanical Engineer can obtain an offer from practically any company he cares to interview. Chemists and Chemical Engineers are heavily sought after by industries to which their training is adapted. Electricals, Metallurgists and Physicists are enjoying the flush of competition.

Aeronauticals are not only in demand by the booming aircraft industries, but are being fitted in other spots where their basic knowledge can be viewed as fundamental. Welding Engineers are so scarce that their services are valued at figures which in normal times are attained only after many years of effort, and every production industry has a welcome sign out for Industrial Engineers. Indeed, few companies these days wait for engineers to come to them; they go to the graduates.

### *Campus Recruitment*

Campus recruitment is not a new experience for many of the old line companies who realized years ago the wisdom of taking their personnel needs to the classroom door and selecting young graduates where the assistance of the professors could be weighed in their consideration. By this means such industries built up a chain of information and interest that carried from class to class as their recurring visits were made. As a consequence, such recruiters have a far easier time of attracting senior students into the interview room than the company who never before set foot on a campus and whose name is unknown to the youthful graduate.

But for the first time, many concerns both large and small, are unable to wait for the nervous rap on the door by the young applicant. This fact quite naturally leads to an investigation of procedure and the en-

## Table I — Code of Ethics for Interviewing Procedures*

### *Responsibility of Industry*

1. Contact the colleges for interview dates at least two weeks in advance of visit.
2. Notify students interviewed within two weeks, offering them jobs, declining their applications, or explaining that they still are under consideration.
3. Give the student as complete a picture as possible of the company.
4. Supply the college placement office with accurate decriptions and specifications of job openings.
5. Visit the colleges regularly, in lean years as well as in good years.
6. Consider the college academic schedule in planning visits.
7. Keep the placement office informed of all direct contacts about employment with students and professors.
8. Hold to schedule of visits.
9. Refrain from asking engineering schools to include courses of special benefit to certain companies.

### *Responsibility of Colleges*

1. Inform industry as early as possible each year of approximate number of graduating students by courses.
2. Encourage students to consider a number of different employment possibilities and encourage each recruiter to give the students an adequate picture of his company.
3. Provide quiet, private space for the interviews.
4. Work to improve the college guidance program.
5. Arrange opportunities for company recruiters to talk with college faculty members.
6. Make school records available in convenient form.
7. Select students from various programs for companies wishing several types of applicants.

### *Responsibility of Students*

1. Learn as much as possible about the company prior to the interview with the company representative.
2. Meet the interviewer promptly and answer company correspondence promptly.
3. Stop scheduling new interviews after accepting the offer of one company.
4. Notify other companies after accepting the offer of one company.
5. Fill out company forms carefully.
6. Accept an offer as promptly as possible, thus accommodating other students, as well as the company concerned.
7. Keep the placement office advised of all negotiations.
8. Maintain a businesslike manner at all times.
9. Recognize that getting a job and getting ahead in a job are responsibilities of the individual.

*Adapted from an article in the Journal of Engineering Education, Vol. 39, No. 7, March, 1949.

lightening knowledge that, with few exceptions, all colleges and universities today afford some type of placement service.

Designated individuals in the various institutions have been charged with the responsibility of establishing a means of bringing new graduates and industries together. Systems vary to some extent but for the most part fall into a similar pattern. Early in the senior year technical and scientific students are lectured on what the general employment picture for the year is. They are counseled on how to prepare for an interview, what to glean from such contacts, the ethics of dealing with representatives through correspondence, plant visits, and other fundamentals. They are advised on matters of professional examinations and other related subjects. And finally the details of making and keeping appointments with recruiters are emphasized.

Informational folders pertinent to the current year's graduates are usually prepared in advance by the schools, and sent out early in the fall to those companies who maintain regular contact. In this connection it is extremely desirable for the industries to assign the same representatives to a specific area year after year so that the working liaison can be built up on a basis of mutual understanding.

While the placement officers are busy on the academic side, the personnel departments of the various industries are developing itineraries for their representatives whose first move is to establish dates convenient to the academic schedule. The biggest factor involved in a smoothly run placement operation is timing. Representatives who outline their plans fully in advance, arrive on time, and keep their interviews on schedule are a delight to have on campus. Group meetings, immediately preceding individual appointments between applicants and company representatives, are common practice in some schools and an untenable one in others. Wise recruiters acquaint themselves with the limitations of the schools and adjust accordingly.

New companies going into the field for the first time during this high pressure period have a rough row to hoe. There is no magic formula by which they can make up for those lost years when their competitors and the academic officials were sitting down together evolving the present college-industry relationship. Within the brief span of time since the start of the second world war placement officials and industries from all over the country have organized themselves into regional groups and met to discuss mutual problems and develop effective methods of operation. A code of ethics for interviewing procedure Table I was established by a selected committee under the guidance of the American Society for Engineering Education. Publications of an informational nature such as "Journal of College Placement" are jointly read by the academic as well as industrial people.

Certainly, however, companies new in the college recruitment scene, are welcome to avail themselves of campus facilities the same as those who have been perennial visitors for some years past. They will find the competition keen and the student response rather small until they have developed a reputation for having a work opportunity that the technical graduate especially wants. The best publicity any company can have on a campus is the enthusiastic good will of its young employees who are alumni.

### *Basic Appeals to Graduates*

The chief concern of every recruiter today is summed up in the question, "How can I approach technical graduates in such a way that my company will attract them to the point of ac-

cepting an offer?" Money is not the determining factor as starting rates have assumed a range within which limits practically all industries remain. Though higher than they have ever been in history they are still at a level throughout the United States, Table II. Naturally, no young graduate is willing to cast his lot with an industry whose offers fall short of that range.

Neither, on the other hand, does he consider salary as the only factor. A company whose offer is materially higher than other concerns will be looked upon with suspicion on the basis that a high starting salary is the only thing that it can offer.

Seniors in engineering and science have been bombarded with industrial pamphlets and publicity schemes that the best advertising minds have been able to devise. These are so numerous that they are not always given more than a fleeting glance. Elaborate colored movies of plant and laboratory operations are offered by the score–but their on campus showing attracts only a small audience: as a matter of fact, many concerns have turned their efforts in these directions toward the junior and senior high schools, with the long range objective of convincing students at these levels of the advantages of a scientific education.

This apparent indifference does not derive from apathy but rather from a sense of frustration – for it must be remembered that students are still at the "school boy" stage where daily class assignments and the stern demands of professors must be met before they are eligible for a degree.

What then is the best approach to follow? The true answer lies within the framework of the following facts. Some years back, pre-war to be exact, the popular youthful desire upon graduation was to seek fame and fortune in far places. The more distant from home and family the more excitingly attractive. In those days a young person's travels had usually been limited. The restrictive bounds of the home town and parental influence were something to be shunned. A man was single, ambitious and raring for the great challenge the industrial world offered. If he had to knock on doors and walk the streets before he could interest an employer in his abilities he was willing to do so – and usually valued the first pay check all the more when it finally touched his hand. He didn't expect too much at first except the chance to make a start.

Contrast all that with the young graduate of today, who has either already seen or is threatened with necessity of seeing, some of the world via military service. In many instances he is married and often times a father of one or more children. He has a deep sense of appreciation for his home ties and does not want to be moved about. Even his home affects him with a certain nostalgic longing. He knows that opportunity abounds on all sides so he begins to analyze his values and make his decisions with these in mind. His desire to earn a good living near his family and friends if he can do so is indisputable.

Of course, none of today's graduates fail to recognize the necessity of going to other localities to obtain opportunities. Training courses, company reputation, chances for advancement all have a distinct bearing on their decisions – but they are no longer the entire basis of choice. A wise recruiter recognizes and emphasizes the home element as much as the industrial. If the prospect is married he would do well to meet, or at least find out something about the wife's wishes for her husband. Wives and sweethearts are helping to decide most important questions these days. It is only natural when one views the picture of a confused young man sorting through a desk full of offers (six to twenty per graduate) trying to decide where to begin. As one engineer expressed it: "I wish someone would hit me over the head and make up my mind for me."

There is a definite art to good recruiting in times like these as well as in any other season. Nothing irritates an applicant more than to be "talked at" without a chance to say a word – or, to be quizzed to the point of a third degree without a chance to hear something of the company and its policies. To accomplish a two-fold give and take in a twenty or thirty minute interview period and keep such a routine up throughout an entire day is a terrific program. Companies, therefore, should select, train, and guide most carefully those representatives who assume such duties. The impression a student gains of a company through an interviewer will often last a lifetime.

**Table II – Approximate Starting Salaries for Engineering Graduates 1948 to 1952**

| Year | Starting Salary, dollars/month | | |
|---|---|---|---|
| | Medium | Average | Range |
| 1948 | $250 | $228 | $225-350 |
| 1949 | 260 | 256 | 250-350 |
| 1950 | 260 | 262 | 250-350 |
| 1951 | 300 | 308 | 275-375 |
| 1952 | 340 | 322 | 300-400 |

Straight forward, honest factual dealing both during the time he is on campus as well as in further correspondence or plant visitation is of the utmost importance. Many companies lost out this year because they allowed too long a time lag between the original contact and the follow-up date. "On the spot" offers are not always advisable (few companies practice this system) but silence, where interest has really been stimulated, is usually costly.

Absolute honesty in outlining future opportunity is most essential. A young graduate who awakens during his initial work period to the realization that he has been sold a false bill of goods soon spreads the word back to his campus and makes further contact difficult. A recruiter should never be afraid to emphasize the work aspect of his offering. As one student remarked after an interview "I was under the impression that company wanted men to go to work. All the recruiter talked about was the fine golf course, vacation time, and sick leave I could expect. I'm looking for a job, not a chance to loaf."

Not all companies maintain large personnel staffs and are therefore limited in their means of contact. In many such instances their top officials or district office personnel drop into placement offices to seek advice on the current group of graduates in relation to their needs. If the school has personnel data sheets (as most of them do) on their senior students, the representative quite often finds it profitable to select those whose interests and degree tie in best with his proposition and send them personal letters asking for an interview at the home plant. Such invitations sometimes state a willingness to pay travel expenses while others, if the prospect's home is nearby, are merely a request for him to drop in when next in the vicinity.

Another first step in approaching graduates is to have the school post a "notice of need" on which a brief statement appears concerning the company and suggesting that an application blank and further information be obtained at the placement office. Some favorable results are realized through this system although they are usually quite limited.

Ads in college dailies or monthly

## Table III — Suggestions to Industry on Procedures and Methods of Contacting Colleges

1. Maintain regular contact with the colleges where recruiting is conducted.
2. Select carefully and train thoroughly the representatives who go to the campuses.
   a. Acquaint them with "The Code of Ethics for Interviewing Procedures."
   b. Teach them how to conduct a concise "give and take" interview.
3. Establish good working liaison between placement offices and industry so that each will have respect for the other's problems and limitations.
   a. Do not make unreasonable demands of a placement office such as full time attention of the staff, additional interview space after arrival, etc.
4. Make clear in preliminary correspondence
   a. Types of graduates wanted
   b. Length of interview period desired
   c. Time of arrival and departure
   d. Any special arrangement peculiar to your needs, such as group meetings, distribution of application forms or company literature.
5. Observe absolute honesty in dealing with applicants
   a. In explaining beginning assignment of work and future opportunity for advancement
   b. By meeting all agreements made during interview such as date of follow-up letter or date for plant visit
   c. By taking into account an applicant's home life and being realistic about it in relation to the demands of the company's program.
6. Participate in regional placement meetings so that established policies of school and industry relationships may be fully known and observed.

journals receive small attention. Several trade publications designed for the express purpose of presenting industrial opportunities to technical graduates are being widely circulated, but net the companies who pay for them only feeble returns.

Technical graduates these days cannot be cajoled nor coerced into a job selection through fancy approaches. In spite of the flattering attention and smug knowledge that they are highly prized there is a well poised brain in most of them that continues to seek out facts and truths. By the very nature of their academic training they have been taught to weigh carefully and analyze accurately before giving an answer.

### *After Employment — Then What*

Once a graduate has accepted an offer and started on his first position as a technical man he is doomed to moments of frustration and disappointment. The first year of work, just as the first year of marriage, is a period of adjustment from which no one can escape. Even though a taste of industry has previously been experienced through summer employment or a year of financial shortage there is still something different about being "launched" for the real test. Companies would be wise to remember the quotation "Young men dream dreams and old men see visions." Reality is never like the dream but a certain compensating balance can often be reached.

Perhaps the greatest mistake industry makes with young employees is to give the impression of forgetting them. Nothing dispels their confidence more quickly than to be given an unimportant assignment and left alone too long. The majority of alumni their first year or two complain only of "not getting anywhere" or "not being used in a way for which their education has equipped them." A regular review of a man's progress in a company during his early years is the best safety device possible. Many times the mere chance to sit down with a sympathetic listener and "sound off" will release pent up emotions and reveal that the excess steam was causing all the difficulty anyway. Those in placement work experience such explosions on the part of alumni almost daily and in a high percentage of cases the graduate returns to his employer.

Discontent with the first job today is quite often stimulated by the family of a man. Where a wife fails to adapt herself to a new community, or the pleading letters of parents urge a relocation closer home, it is sometimes emotionally impossible to hold out even though the work is definitely to his liking.

Other causes for leaving a company in the early months are inability to adjust to personality characteristics of superiors, lack of satisfaction with type of work, sudden realization of company policy that limits chances for advancement beyond a certain point, a feeling of insecurity, unfavorable health conditions in particular climate, dislike for travel or uncertainty of location after a training period.

To a seasoned employer who experienced all these conflicts some years earlier during his initial working days but who stayed with the job, these appear as perhaps childish and immature, but the fact remains that the technical graduate of today knows he can come fairly close to the realization of his desires and he is not readily willing to settle for less. All in all, however, he is just as sincere in his hope that the first position he accepts will be the right one as the company who employs him and in a high percentage of cases he proves this by remaining throughout the years.

The searchlights of industry are truly swinging in wide arcs these days in their attempt to light the pathway of young graduates to their doors – and if youth seems somewhat blinded by the brightness of the beams it is not to be wondered at. To receive the plaudits and homage of seasoned men while one is at the embryonic stage simply because of having completed a curriculum in science or technology must naturally throw the industrial world somewhat out of focus. The fundamental stability which for many generations has proven to be an innate quality of American youth must serve it in good stead today, while the phenomenal capacity of American industry to meet and adjust to periods of difficulty is bound to see it through the stress of the next few years.

FISHER BODY CRAFTSMAN'S GUILD

# What Must Be Done to Solv

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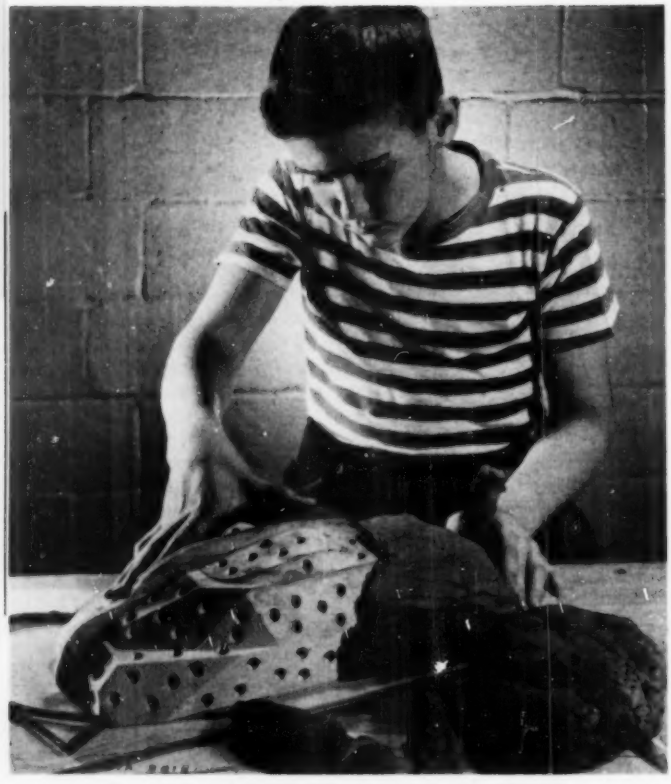


**Fig 1 – The Craftsman's Guild, with over $20,000 awarded in prizes, is one method GM uses to stimulate interest in engineering. Awards are given for proficiency in design. Fig. 2 – Young entrant sands his miniature automobile to a satin-smooth finish. It is his big opportunity to win a prize award. Contest is sponsored by Fisher Body Division.**

**Fig 3 – Model builders see how a real car is put together. Plant tours are often arranged on a local basis to arouse student interest in the planning of large scale production. Fig 4 – Harley Earl, vice president in charge of styling, shows General Motors' experimental dream car – Le Sabre – to a group of youthful contestants on tour of the auto industry.**

# to Solve the Engineering Manpower Problem

**CHARLES A. CHAYNE**
**Vice President in Charge of Engineering Staff, The General Motors Corporation**

*The engineering staff head of the world's largest manufacturing corporation discusses the programs that industry must undertake to insure full utilization of engineering manpower and to increase the number of students entering the engineering colleges.*

THE SHORTAGE of engineering manpower is unquestionably the most vital problem facing the United States today. Entirely aside from the demands of the defense program, modern business needs increasing numbers of men with technical knowledge for careers in design, production, sales, and management. To maintain our present world leadership and to improve our standard of living will require a tremendous productive power built on science and engineering.

Yet despite this impressive demand and opportunity, there is little evidence that more than the usual percentage of high school graduates are selecting engineering as a field of study in college. This situation can be corrected only if industry as well as educational systems and institutions undertake a program of acquainting the high school student with the advantages of a technical education and the rewards open to him in industry. At best, students of high school age have only a hazy conception of engineering as a profession. Some of them find out too late and have not included in their curricula enough mathematics and science to meet the engineering college entrance requirements.

There are many techniques that industry should use to stimulate in-

**Fig 5 — A class at the GM Institute, where outstanding high school graduates are provided a cooperative course in technical fields. Many other industries have similar programs.**

**Fig 6 — Providing background information to teachers at national and regional meetings helps them to properly counsel their students and to appraise the field of engineering.**

**A recent Navy Research project—broadcasting sound on a beam of light – is explained and demonstrated with music.**

**The story of 2,200 years of jet propulsion from Hero's aeolipile to a modern Dynajet. Traveling displays of this type bring the story of industry to the engineers and executives of the future, such displays influence them to study engineering.**

terest in engineering as a profession. First and foremost, it must establish the engineer on the same level as the scientist. With the coming of age of chemistry and atomic physics, the public has become aware of the influence of the scientist on everyday life. Radio and television programs, newspaper and magazine articles, and even Congressional hearings have been devoted to the views of the researcher and scientist. But industry has been lax in using the same means to impress upon the public that the engineer is the man who takes the idea and converts it into a product that can be used in the office, factory or home – that he, with the facilities that industry provides, represents the difference between this country and Great Britain or France, where scientific knowledge is not successfully translated into products and productive capacity.

The opportunity to make a good living, to contribute to the general welfare of the country, and to be a respected member of his community is open to any graduate engineer. Many of the methods used by General Motors to impress these facts on the high school student are available to any company:

1. Providing students and teachers with literature on scientific developments, production techniques, or products. A booklet that was written specifically to give students a better conception of the engineering profession and industry is "Short Stories on Science and Invention" by Charles F. Kettering.

2. Supplying educational institutions and parent-teacher groups with motion pictures.

3. Sponsoring of radio and television programs such as Henry J. Taylor's "Your Land and Mine." Reprints of these programs have been made available without cost upon request. Millions of listeners have heard these broadcasts, which were sent out over some 180 stations.

4. Developing traveling science shows such as "General Motors Preview of Progress," which has traveled from coast to coast and has unquestionably directed the thoughts of many high school students toward science and engineering. This show consists of displays and demonstrations of scientific developments and phenomena, and is accompanied by lectures.

5. Exhibiting at national education conferences to impress teachers and educators with the requirements of industry, and especially with the need for counseling their students to take mathematics, physics and chemistry.

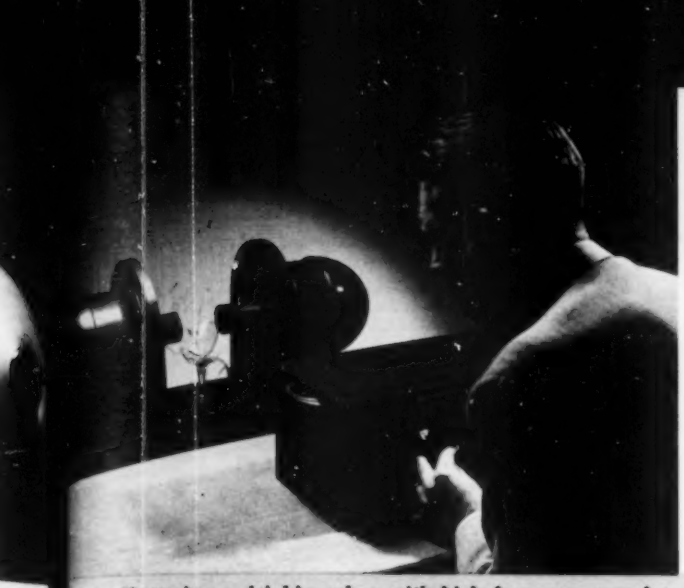
6. Sponsoring Business-Industry-Education Days, during which both teachers and students are taken on conducted tours through local plants.

7. Employing teachers and professors, insofar as possible, during vacation periods to assist them in understanding the techniques and objectives of industry.

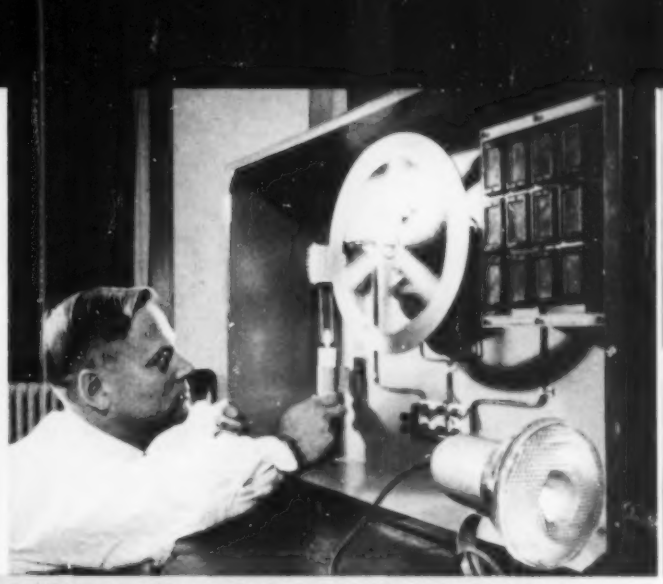
8. Sponsoring competitive college scholarships that are open to high school or grade school students and are designed to stimulate the interests of such students in engineering. Examples are the Craftsman's Guild Contest, sponsored by the Fisher Body Division of General Motors, and the Soap Box Derby, sponsored by Chevrolet. A somewhat allied but different undertaking is a program whereby high school graduates are selected and sponsored by various operating divisions throughout the country and sent to the General Motors Institute at Flint, Michigan, for a cooperative course in technical fields. Many industries have chosen closely similar programs.

9. Providing responsible engineers and department heads to lecture before teachers conventions, student meetings, and assemblies at engineering universities. These lectures give the student a better conception of the needs of industry, the basic requirements for success in engineering and the opportunities offered by an engineering career. The lectures do not confine their presentation to General Motors but present the picture as it applies to industry in general.

10. Inaugurating or partially underwriting national exhibitions that further the prestige of science and engineering, such as the Centennial



**Shattering a drinking glass with high frequency sound to illustrate effects of mechanical vibrations is one of the many demonstrations in the General Motors traveling show.**



**Sunlight, lamplight or heat from a candle is converted into enough electrical energy to spin the light flywheel of the Sun Motor now being shown throughout the country.**

of Engineering which will be held this summer at Chicago.

### *At High School and Industry Levels*

The high school level is only the beginning. One of the most important decisions a college engineering student must make sometime before he graduates is that of selecting the field of work for which his background and abilities qualify him. Anyone who has interviewed engineering graduates has received the impression that too many give little thought to this problem until just before they graduate—that they have little conception of industrial organization and work, and that they place too much reliance on industrial training programs to provide the answer.

Generally, a training program includes a period of induction and orientation, providing the graduate with basic information concerning the work and functions of the company; an opportunity to gain experience by varied work experience in major units and key departments; periodic meetings with members of management to discuss manufacturing and engineering problems and to broaden his knowledge of them; and finally, assignment to a regular job.

Colleges, however, should continue through their guidance clinics and faculty counselling to encourage undergraduates to give early thought to opportunities to check what is actually involved in each phase of engineering work, and to get at first-hand some practical experience and knowledge.

Similarly, industry should recognize that the transition from campus to industrial life involves an important individual adjustment, and that much of the restlessness and impatience observed in some engineering graduates is traceable to this. To the extent practical, industry should encourage and provide opportunities for summer employment as a means of early indoctrination and orientation, and management follow-up and counselling of the graduate not only during the course of his training program but afterward—while he is finding his niche in the organization.

On the other hand, the engineering graduate must realize that while he will be given assistance in making this transition from directed development to self-development, he must be ready to assume his full share of responsibility. He should keep in mind that he is employed not for his immediate value to a company, but because it is believed he has potential for some future responsibilities. To attain these positions of responsibility he must compete with many others. His college education should be helpful to him in arriving at his objective, but it will not guarantee him success.

Modern industry is complex. Today there are very few "lone wolf" jobs left. It takes more than ability in a particular field of work to get ahead. It takes ability to get along with other people—first in working with them, later in directing the work of others. It also requires the ability to sell oneself and ideas. It takes time for the graduate to prove himself in these other respects—and he cannot progress far until he does.

Industry's responsibility in this situation, therefore, is not to develop the man, but to provide opportunities for him to develop himself. The present technical manpower situation is one requiring the full utilization of the maximum capacity and ability of every engineer. It is one that necessitates industry, to the extent practical, making certain that engineers are used in engineering work; that they are transferred from positions that may not require engineering training to those that do; that they are held in "intern" positions no longer than necessary to qualify them and then moved to positions of maximum responsibility compatible with their ability, experience and existing opportunities; and that junior technicians are assigned to the less technical aspects of the work. It is a situation that will require also constant training activity in every phase of technical work to develop all employees with potential skills and to fill special or emergency needs.

Under such circumstances there is unusual opportunity for the engineering graduate who can prove himself.

The task of training such men must be shared by both colleges and industry. Those two institutions will have to solve the problem. The colleges have been doing their part about as well as can be done with the funds they have available. It is now up to industry to make it unnecessary for the colleges to seek federal support with all its potential penalties.

# Training Today's Engineers

*Once the young graduate is hired he must be trained by the company to be usable at a maximum potential. Training occurs in three phases: pre-employment, post-employment, and continuing advanced training.*

COMPETITION AMONG COMPANIES on college campuses has everybody looking for new methods of getting their share of young engineers. Currently employed personnel are being used to a greater extent in searching out new talent. Employees designated as college representatives visit two or three specific campuses several times a year to talk with faculty members and to sell the company to them by stressing working conditions; opportunities available; and beneficial company policies. Prestige and approval built up with the faculty results in favorable recommendations for the company. An alumnus familiar with a particular campus and faculty may be assigned to do this job.

Sales representatives throughout the country, and plant personnel at locations away from company headquarters are used as part-time recruiters to make the company's coverage nation-wide. This emergency staff is briefed on recruiting by special instruction booklets that contain everything the representative should know in contacting students and faculty members: how to set up interviews; general company policy; procedure for hiring; the company's standards; and what to look for in the students personality and background.

But regardless of how the engineer is recruited some kind of training is required to acclimate him to industry and enable the company to utilize available help to a maximum potential. Starting with an introduction of the young graduate to the company, today's educational program continues throughout the engineer's career preparing him for supervisory and managerial positions.

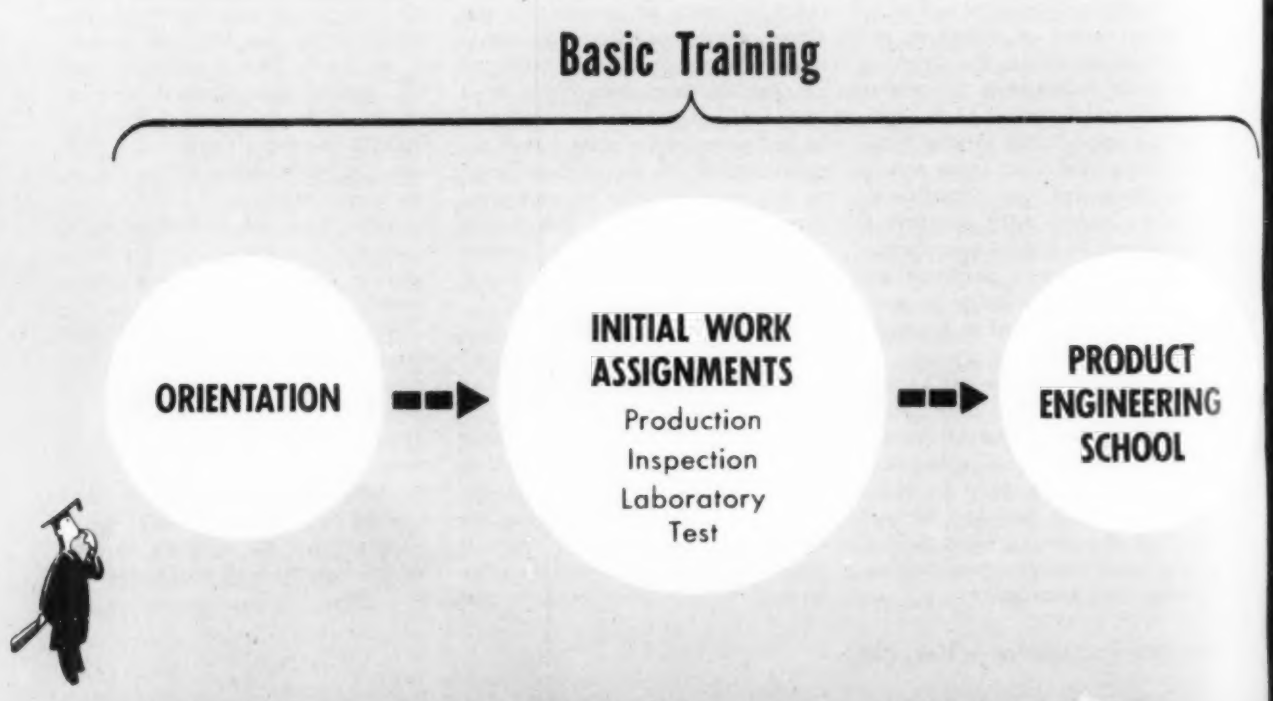
Continuing educational opportunities are an incentive to prospective employees; assure a progressive, up-to-date engineering department; and enable the company to produce management personnel from the ranks.

Training can be classified into three stages: pre-employment, post-employment, and continuing advanced training. Most important requirement of any program is the active support of management, particularly top management.

### *Pre-Employment Training*

Training before permanent hiring is used as a means of getting the jump on competition in obtaining their share of young engineering graduates.

Cooperative education offered by many colleges and universities is a formal pre-employment training pro-




**Schematic diagram of the post-employment training program used by Westinghouse Electric Corporation to indoctrinate young engineers. Specialized training includes classroom work and work assignments. Several hundred new engineers take this course every year.**

**Westinghouse built this educational center to house classrooms and library for their post-employment training program. Employees studying for advanced degrees also hold classes here.**

gram. A complete listing of these schools can be found in the report "A survey of Cooperative Engineering Education," Bulletin No. 15, prepared in 1949 by the Office of Education, Federal Security Agency. After the freshman year, the student alternates three (or six) months periods in college and at actual work in an industrial plant. Usually five years in length, the course enables a student to gain two years of industrial experience before he receives an engineering degree.

Obvious advantage to a participating company is the hiring of a young graduate who is already familiar with the company's organization, products and procedures and who can step in and carry his share of the engineering load almost immediately.

Another method of pre-employment training involves hiring students in the junior year for summer work as engineering assistants. While the student releases experienced engineers for pure engineering assignments and gets acquainted with the organization, the company observes his capabilities and evaluates his potentialities as a future employee. At the same time, the young engineer is indoctrinated into industrial procedure and gains actual experience.

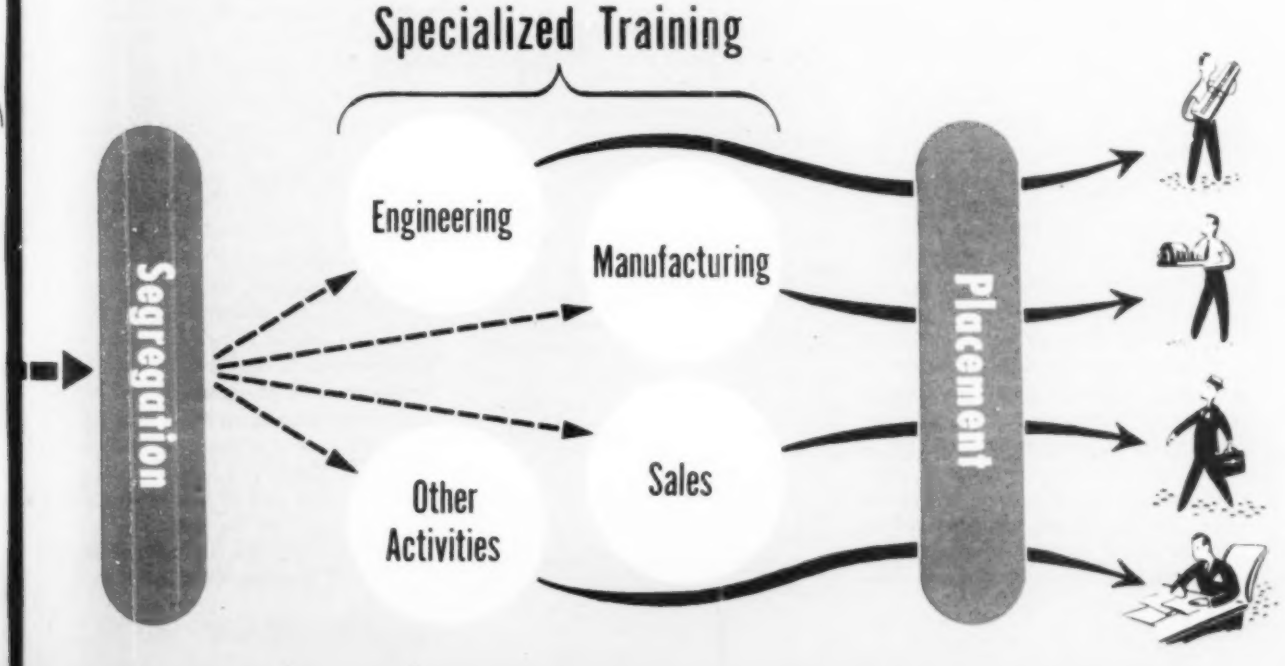
Pre-employment training is most frequently used by small companies who feel that the training facilities offered by large corporations put them at a disadvantage when it comes to hiring young engineers. By using these methods they feel they have an opportunity to reach the student and sell him on their company before he may be contacted by a larger corporation.

***Post-Employment Training***

The gap between college classroom and industry engineering department is bridged by a graduate student training program lasting from one month to five years. Purpose of this course is to provide the novice with a solid background in company operations, organization, policy, products and services.

Experience indicates that young graduates usually do not know exactly what they want to do so the course must evaluate each man's interests and locate him in the best possible job based on those interests and his qualifications. Some specific training not available in college or university curricula is provided to enable the novice to start the job.

Members of the company who are specialists in the fields to be studied teach the training courses on a graduate level. Classroom work is combined with actual work assignments. Course material varies with the company but in general, all post-employ-



ment training courses cover these general points:

I Individual counseling throughout the course. Measures the student's ability and grasp of what he is learning, and determines his interests for permanent assignment

II Orientation

A. Description of the industry the company is a part of.

B. Company background and general policies including employee benefits, advanced training opportunities, promotions, vacations, etc.

C. Functional company organization.

D. General product lines.

III Classroom Technical Training

A. Design and engineering details of the company's products (what they look like, how they are built, how they function, performance record, how they are installed, how to apply them, what customers use them, competition in the field, markets, outstanding features).

B. Competitive products—description and discussion.

C. Specialized technical training for a specific position in the company, including background and advanced material.

IV Work Assignments

A. Work for a short period of time in many different departments to acquaint students with the variety of work available. One assignment is usually in a test department where trainee evaluates products without necessarily doing the actual testing. This work conveys a pattern of thinking to the student and teaches standards of performances and how to judge them.

B. On-the-job training for longer periods in various phases of the type work selected by the student for permanent assignment.

Length of work assignments is based on positions available, individual's previous training, experience, aptitude and interest.

V Permanent Assignment

Training an engineer at the start of his career appears to induce a greater degree of company loyalty and esprit-de-corp in the working force. One large company with a program that lasts almost a year found that less than five percent of the trainees left the company before the training period ended and the majority of these terminated employment because of family or geographical reasons. Less than 25 percent left during the first five years of employment, and only an additional six percent left during the next five years. Well over half the trainees spend their entire engineering career with the company.

Obstacles to be avoided in a program of this kind include:

(1) Work assignments that do not challenge the capabilities of the student.

(2) Over supervision that bars the development of self confidence.

(3) Disappointing recruits by painting too rosy a picture of the company's operations.

(4) Relying on the ability of a student too much; many do not live up to expectations.

Small companies have recognized the advantages of a post-employment program but have felt that it is practical, financially and personnel-wise, only in large companies. Actually a small company program can be inexpensive and possess big advantages over the large company course.

Not using "pool hiring" the small employer hires for a specific job, and can eliminate some of the variety of work assignments. Pre-employment training digs out the right man for the job and reduces the amount of company orientation required. Training can be given on a very personal and individual basis with conferences and interviews taking the place of classroom work. And one person can administer a small training program in addition to his other duties.

**Schedule of temporary work assignments for Square D Company's new engineers. Though averaging only eight new engineers each year, the company puts each man through a complete orientation program. These assignments are one part of the program.**

STUDENT ENGINEERS
TRAINING SCHEDULE

NAME..... CLOCK NO.....

| DEPARTMENT (Grp. No.) | TIME REQUIREMENT (Weeks) Short | Long |
|---|---|---|
| Regulator (26) | 1 | 2 |
| Timers & Coil Wind'g. (32) | 1 | 1 |
| Standard Assembly (28) | 1 | 2 |
| Standard Assembly (29) | 1 | 2 |
| Special Assembly (31) | 1 | 2 |
| Special Assembly Job Shop (65) | 1 | 4 |
| Test Room (35) | 2 | 3 |
| Inspection (44) | 1 | 2 |
| Short Orders (37) | 1 | 8 |
| Laboratory | 3 | 3 |
| Drafting | 2 | 2 |
| Time Study | 2 | 2 |
| Prod. Plan'g. | 2 | 2 |
| Total Weeks | | |

### *Continuing Advanced Training*

Advanced training encourages engineering personnel to develop with the company and with their science.

On-the-job training of all personnel is a prime responsibility of all supervisors so that employees are constantly being educated and trained.

Technical meetings and professional societies are recognized as another source of advanced training. Many companies pay membership fees and travel expenses to out-of-town meetings as a method of inducing employees to join and actively participate in these groups. Industrial publications and association journals keep personnel informed of latest developments and afford a place to interchange information.

Educational facilities are made readily available by the establishment of out-of-hours courses. Presented on a graduate level by specialists employed in the company these courses demand a high standard of scholastic effort and achievement.

Size of classes are limited by a review of applicants to insure that those enrolled for a course are adequately prepared by training and experience to benefit from it. Active participation in classroom discussions is an important part of the program.

In one such program established by Bell Laboratories, the courses are offered without charge to employees who sign up on a voluntary basis. Class members use their own time for study and preparation, and the instructors are employees of the company who serve without extra compensation. Texts are loaned and returned at the end of the course, or are purchased by the students.

Supplementing the Bell courses are a series of lectures concerned with

**Bell Telephone Laboratories Out-of-Hours Courses**

**Review of Engineering Mathematics (2 terms)** – A review of engineering mathematics taught in undergraduate college courses.

**Oscillations and Waves (3 terms)** – Proper methods of analyzing wave phenomena irrespective of their special physical nature.

**Electronic Circuits (3 terms)** – Design methods for circuits using electronic devices.

**Manufacturing Methods (2 terms)** – Covering modern manufacturing methods and the manufacturing organization of the Bell System.

**Fundamentals of Television (1 term)** – Perception of light and color; television signal transmission; television standards and apparatus.

**Development Economics (1 term)** – Basic theory and methods of applying principles of economics to development work in the Bell Telephone Laboratories.

**Freehand Sketching (2 terms)** – Develops ability to present ideas graphically.

**Laboratories Staff Operation (1 term)** – Series of informal lectures about the major duties of each department.

**First Aid, Standard Course (1 term)** – Standard first aid course of the American National Red Cross.

selected phases of the company's activities. These seminars advance the state of technical knowledge of the employees and keep them informed of the company's activities.

Advantages of out-of-hours courses can be obtained even if it is not feasible to set up a company-contained program. The company can encourage engineers to take courses at nearby colleges by offering to bear the entire cost or share the expense of the course.

Encouraging engineers to seek advanced degrees is another method of continuing advanced education. Linking graduate study and thesis research with his job, the engineer applies advanced principles learned in the classroom to problems encountered in his daily work.

Usually an arrangement is made to share the costs of advanced degrees when obtaining the degree will mean benefits to the company. Either of two methods are generally used: sharing a percentage of the tuition; or granting time off during the working day to take the courses.

In one graduate study program, the company has contacted a local university and set up special graduate courses for its employees. Aimed at the company's particular operation, these courses are accredited by the university for advanced degrees; supplement the advanced degree course; and are taught by company specialists.

### *Supervisor Training*

Adequate supervisor training courses have been established to cope with the growing complexity of labor relations and engineering developments. Feeling that technical ability alone is not sufficient to make a good supervisor, management people have worked out courses with the aid of psychologists and industrial labor experts.

Supervisors, courses generally cover:

I Human relations in management. Helping the employee to adjust to his job; principles of effective management; understanding the employee and his problem; etc.

II Company policies and their interpretations.

III Duties and limitations of supervisors.

This special course is augmented by out-of-hours courses and advanced degree courses. Follow up of an initial supervisor course by discussions and seminars has resulted in maintaining supervision at a high level.

### *Management Training Courses*

Training continues right up to top level management with selected universities offering special executive courses that last as long as a full year. In these seminar type curricula latest techniques and principles of management are thoroughly discussed and scrutinized.

A new concept in employee training is developing about so-called economic education programs. Purpose of these courses is to point out the benefits of the free-enterprise system and to correct mistaken impressions about the company's financial operations. While many manufacturers have experimented with programs of this type in the past two years, none have been entirely satisfactory.

The problem is this. If economic educational material is not carefully prepared and presented, it assumes the tone of obvious propaganda and can bring about labor unrest. Authorities now agree that such a program must be a continuing effort rather than a one-shot course. Several research organizations are now preparing and testing educational programs of this type for some of the larger manufacturers.

Advantages of continuous training from hiring to retiring can be summarized as:

(1) Supplies the necessary quota of high potential young men without which a company cannot exist.

(2) Provides at the outset a background on the industry and company policies to the young graduate.

(3) Imparts a broad familiarization with the products and services of the company so that each man has a working knowledge of the company's overall operation.

(4) Develops company loyalty in the trainee because of managements obvious investment in time, money, interest and patience, and keeps turnover low.

(5) Influences behavior of trainees through close association with older experienced employees who have professional recognition.

(6) Instills healthy attitude through emphasis of opportunity and rewards of doing a job.

(7) Enables the trainee under guidance to explore all possible job opportunities so that ultimate placement is most satisfactory to him and company.

(8) Produces top management people from the company's own organization.

**Fig 1. (Left) – The most difficult problems are found on the space relations test against a 30-minute stop watch time. The diagrams on the examination sheet are opened-up figures that must be folded mentally to make solid forms. This is a test that helps in estimating design abilities.**

**Fig 2. (Right)–Picture story test, which lasts about an hour and is not timed against a stop watch, requires engineers to create stories on each of 8 pictures. This discloses indirectly various aspects of the engineer's personality. No intent is made to grade comprehension of grammar.**

# To Place Graduates Properly:

*The Wright Aeronautical Division of Curtiss-Wright Corporation is applying psychological testing to the graduates who came in on their training program last year. Object: placement in the proper engineering job in six months—not two years—as was the case when observation was the basis of assignment.*

SCREENING TESTS are an excellent supplement to trained judgment and observation prior to the permanent assignment of engineering graduates in industry. That's the preliminary conclusion of supervisors and department heads at the Wood-Ridge, N. J., plant of Wright Aeronautical, after analyzing results of a program inaugurated last year to test the several hundred graduates who came in on the company training program, as well as experienced engineers within the company who requested the analysis.

Assignment to engineering positions is being made much more rapidly than in the past. Dissatisfaction with assignment has materially decreased. And comment from the supervisors is generally favorable. Sample: "I can find out more about a man in one day than I formerly could in two years of observation of his personality and abilities.

Under the general direction of industrial psychologists at Stevenson, Jordan, and Harrison, a New York management consultant firm that is administering the program, the tests were chosen specifically to provide an answer to the question of where best to place a graduate after he reports to work.

The former procedure at Wright was to place all engineering graduates in the test house for as long as 1½ to 2 years. During this time, test house supervisors attempted to analyze the abilities and interests of each man. At the same time, each man supposedly was trying to match his interests with the openings available in the various engineering divisions. Although this procedure is conservative and common to industry, it required considerable time and sometimes resulted in error.

The new procedure does not bypass test house assignment, but supplements it with a battery of tests to determine: (1) general and engineering ability; (2) interests; and (3) personality. These tests, which require the best part of a day to complete, are entirely voluntary.

### *Types of Tests*

Requirements for the various types of engineering jobs in the company were analyzed before the program was started. From these, the overall mental and personal characteristics required of engineering graduates in each division were established. As a further check, tests were given to the supervisors and some of the personnel in each department to obtain a correlation between test results of the graduates and the engineers.

*Ability tests* are aimed at determining general mental ability, sometimes called IQ, plus specific engineering ability and know-how. They are broken down into (1) general mental ability tests, and (2) engineering aptitude tests. In the first category are verbal problems that must be solved by reasoning and judgment; and written tests on arithmetic, reasoning, and vocabulary.

The arithmetic test is simple; about 20 per cent of the graduates get a perfect score. There are some engineers however who miss one or more questions, and since mathematical ability is the key to engineering, the results indicate whether a man has the base on which to build. Surprisingly, some graduate engineers have little or no engineering aptitude or interest, even though they have completed a regular four-year course in an accredited university. Transfers are frequently arranged for these people where they have aptitudes of value in other departments.

The reasoning problems are based on mental agility, as opposed to memory, and consist primarily of spotting progressions or patterns in numbers, words or letters. The vocabulary test, which seems to be largely a memory test, measures recognition of word meaning which has been shown to be closely related to

# Try Screening Tests

general intelligence. Mechanical comprehension is tested by relatively easy questions in physics which require the application of mechanical principles to concrete problems.

Finally, there is a space relations test which requires the subject to visualize what would happen to a two-dimensional drawing if it were folded in certain ways to make a three-dimensional figure. Graduates who know descriptive geometry and who can visualize a projected design from a sketch or print usually get a high score. Good scores are believed to indicate good potential design talent.

*Interest Tests* are a means of determining both vocational and avocational – or "hobby" – interests. One engineer described them as "tests that tell whether you like to sell tickets and meet the public or fix up the change machine if it breaks down." But more than that, they indicate the probability of a graduate being successful in the broad areas of sales, office occupations, engineering, production or other trades or professions.

One test, the Strong Vocational Interest Blank, is made up of 400 items to check, such as likes and dislikes. It represents a cross-section of one's thinking, or interests and attitudes. It was given to large groups of successful people in various occupations to discover in each case how the members of that group differ in their thinking from people in general. In that way it was possible to work out a scoring key for each occupation. What the test does is to indicate whether a man thinks like successful people in his work.

The other test is more superficial. It merely presents various kinds of activities, and the subject indicates which one he likes or dislikes for either vocational or avocational purposes. Thus the kinds of information on the two tests are complementary.

These tests are supplemented by verbal questioning to determine the degree of the graduate's interest in hobbies and outside activities. For example, sometimes the graduate has few interests, which may indicate an apathy or lack of zest for living. On the other hand, he may have too many interests, tend to dissipate his abilities and divert too much energy from his job.

*Personality Evaluation* is done partly by interview and partly by written tests. A lot depends on the interview. This is not a superficial employment-type but rather a clinical or "depth" interview in which the psychologist tries to get below the surface. The man's personal history form, which is set up to give his personal background, is reviewed with him to give structure to the interview.

This is followed by two tests, one of which consists of two parts – questionnaire and hypothetical situation. The questionnaire is a check of self-sufficiency, socialability, leadership and initiative, drive or energy level, naivete, detail-mindedness, and persecutory trends or attitudes. On the second part, which might be termed the verbal situations test, the graduate is asked to indicate how he would handle certain situations for which there is no definite answer.

Finally, for the last test, the subject is requested to look at a series of pictures and indicate what might be happening. Unconsciously, he draws on some of his own personal material and projects some of his own personality into his interpretations. This indirect approach has the advantage of catching the person off guard.

Together, these personality evaluations give a picture of the graduate's emotional and social characteristics.

***What Is Done With the Test Results***

Test results are first discussed with each graduate. The confidential report is then shown only to engineering management personnel. These reports take into account age and general development. A report may state that a man has excellent ability and potentially is a well-rounded individual, but that he is somewhat immature. Or it may state that he is something of an introvert, or that he needs to work with other people, or that he would do well on his own. It tries to place him, insofar as intelligence and knowledge of engineering are concerned, in respect not only to the general population but also to the other engineers at Wright.

The report may show that a man is excellent in design, or that he may advance more rapidly in development or research. In some cases, the reports have indicated that the graduate has no preference for engineering and no ability to make significant contributions, but would probably do well in the sales department. To date, the engineering division has transferred 10 of the graduates to other departments within the company.

There has been little or no resentment to the screening tests on the part of the graduates; they accept them as a routine check. Perhaps the reason is that the Wright Corporation encourages the supervisors to use results like an X-ray to reveal traits and hidden abilities that might otherwise not be apparent until after prolonged observation and performance.

Besides the uses previously mentioned, these screening tests also provide data on men who are potential administrators and technical supervisors so that they may be watched. For the man himself it is a form of "career guidance" – it tells him something about himself that he usually does not know, increases his self-understanding, and makes suggestions about the direction of his future efforts.

# Engineering Reports Are Vital to Good Management

J. B. HOLDING and J. D. WALLACE, Battelle Memorial Institute

*Large and small companies alike can implement engineering policies through a system of reports, each keyed by reason of its length, content and terminology to perform a specific function.*

MANAGEMENT TODAY faces many new problems resulting from rapid advances in technology. Company executives are therefore paying increasing attention to the use of reports as a means of communicating technical information throughout the engineering department and other phases of business organizations.

The president or vice president of an industrial concern might issue a report on the overall company objectives and how they are being met. This type of report is generally distributed among the top executives, supervisors and technical people who are directly concerned with choosing and carrying out objectives.

Another kind of report, prepared by a department head such as the chief engineer, would show the activities and developments of his unit and recommend changes when necessary. Or a project engineer might report his particular activities to the department head, also including suggestions for changes in procedure. In each instance, it is important that copies of the reports be circulated up and down the lines of communication so that all who should be informed are informed.

When top management assigns a specific project covering one or more departments, an up-to-date system specifies that reports can be initiated at any point along the lines of communication to provide automatic "progress" or "phase" information.

Well-written and complete reports save considerable time for the evaluation, analysis and solution of technical problems. They help all individuals concerned to tackle a large number of problems effectively and serve as permanent records that are indispensable on many occasions.

All too frequently, those responsible for setting policy believe their organization is either too small to justify writing reports or, because they have never used engineering reports, they see no reason for adopting them. They fail to recognize that there are different types of reports, that each type serves a definite purpose and that a report can be tailored for a specific audience.

### *Types of Reports*

Reports can be classified according to need into three broad groups. The first is the routine report that outlines the activities of an engineering department. This type of report is prepared at regular intervals and is directed mainly to the company's technical director who, in turn, relays the information to top management in revised form.

The routine report need be neither fancy nor lengthy, but it should be concise and well-organized. Its content should be limited to a straightforward factual presentation of accomplishments and plans, with only a short introduction or summary. Management is becoming increasingly aware of the value and need for this type of report.

Second, there is the special report. Problems of special urgency or of particular interest to a company executive, and any matters that are not directly concerned with the routine activities of the engineering department, fall into this category.

A company's technical director may wish to have a summation of work done to date on a given project. Such a report would be classified as "special" and contain: (1) An abstract preceding the body of the report; (2) an introduction that defines the problem and gives its background; (3) an experimental section that presents the actual research and development work done, along with an interpretation of the results; and (4) a set of conclusions. The report should also include tabulations of all significant data, line drawings indicating trends, engineering calculations, graphs, sketches and photographs.

In general, the special report is usually directed to the company's executives and is one of the most important and direct lines of communication between management and the engineering department. This is the type of report that management frequently uses as a guide to determine whether to pursue or drop a

**Technical reports serve top management in two ways—for communicating matters of policy down the line to the engineering staff and for keeping tabs on development projects through progress reports sent up the line at regular intervals.**

project. The importance of the special report to both the engineer and the executive can hardly be overemphasized.

Whereas the routine and special reports are forms of "internal" company communication, the third type of report – the engineering economic survey – is of the "external" type. For example, it might contain an analysis of the selling appeal of the company's products or evaluate the demand for and advisability of placing a new product on the market. Or it may be used as a business barometer to tell whether the time is ripe to establish a new division within the company, to move to a new field or to obtain the controlling interest of an available, already-established technical enterprise.

The economic survey report is usually prepared by specialists in several fields – a market analyst; a statistician; a metallurgical, mechanical or chemical engineer; and perhaps an industrial consultant. Others may contribute if the subject of the report calls for highly specialized information. Tables of data, photographs and sketches, cost figures and production estimates are, of course, important factors in presenting certain types of information.

Because the survey report needs specialized, high-caliber authors, it is frequently prepared as a joint effort of department heads in a company, or "farmed out" to one of the independent research institutes that specializes in this type of work. It is directed primarily to the board of directors or other policy-forming group of the company, and may be followed by a second, shorter report to answer specific questions posed by the board members.

### *Case Histories*

Three hypothetical companies – A, B and C – illustrate how the three types of engineering reports can be used. Company A employs three technical people – a chemist, a chemical engineer and a mechanical engineer. The three work as a team under the supervision of the company's president or vice president. Communication is mainly by word of mouth.

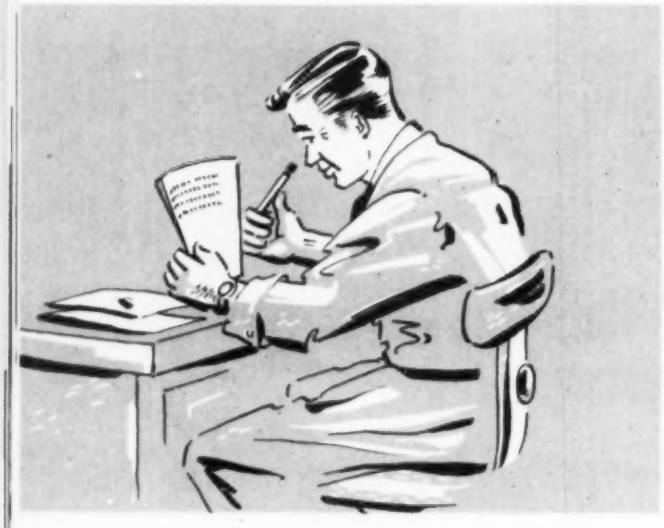
A great deal of work consists of routine testing or "trouble shooting," but the company's officers are also interested in developing new or improved products. Research and development carried out by the three-man team may extend over a considerable period of time, so it is difficult to maintain continuity of work. And several projects may be carried on at the same time, adding to the general confusion.

How is Company A to make best use of the work of its technical team? Are data to accumulate in various notebooks until the executives have time to go over them or until a conference can be held to discuss the work? Although the company is small, its executives are busy and they usually cannot afford to spend much time verbally "rehashing" a six-month engineering project. Nor can they be expected to interpret an assortment of scattered data.

Some sort of a report system is necessary, but it is obviously impractical and unnecessary to prepare long and detailed reports. The answer is the routine report, a short, concise summary written at regular intervals, stating recent accomplishments and plans for future work.

There are thousands of industrial organizations that are comparable in many respects to Company A. Those that grow and prosper in business are generally the ones that let their right hand know what their left hand is doing, by means of routine engineering reports.

Company B, a good-sized manufacturer of domestic stoves and other heating appliances, may employ 50 technicians – chemists, mechanical, ceramic and metallurgical engineers, and perhaps fuel engineers. The situation here is different than with Company A. Company B has progressed from the stage of communicating engineering results verbally. The routine, short report is already a well-established custom because the technical director finds he needs them to keep track of what goes on



**Routine reports circulated periodically keep engineering department supervisors posted regarding the significant details of projects currently in process of completion.**

**Special reports present to management all the information needed to fully evaluate the merits of a new project or analyze data obtained in the course of a completed project.**

in his laboratory. He has found, as have many in similar situations, that this type of report is an indispensable tool in his work. Prompt and regular reports on the analysis of sheet-steel deliveries, on firing characteristics of new enamel and frit lots and on testing of insulation compositions and thermostats must reach his desk. Company B is then able to meet its production schedules by anticipating and solving its manufacturing problems, and to maintain the high standards that insure quality products.

Company B finds, however, that merely turning out good appliances is not enough. It must have a better stove because competition is stiff. The research and development staff is directed to design a better, more attractive stove. The ceramic engineer works to develop an improved base for the standard enamel. The fuels engineer works with the mechanical engineer to design an oven with a higher heat rating and a more efficient burner. The chemist and metallurgist combine their talents to find a different type of sheet steel to meet new corrosion and temperature conditions. The progress of each activity is regularly communicated to the technical director in short reports until the whole project has begun to take shape. At this point, a special report is prepared. This composite report goes to the company executives responsible for technical development, who evaluate the overall development picture, make recommendations for further work and begin to consider the overall economic picture. If necessary, more development work may follow, terminating with a report that either recommends or discourages, on a technical basis, production of a new-model stove.

Company B's operations would falter without an efficient communications system composed of routine and special engineering reports. It might seem that the system as outlined is obvious, and that all companies naturally follow this practice. Such is not always the case.

Company C is a large steel manufacturer employing hundreds of technical people who work in laboratories, pilot plants and full-scale manufacturing units in various parts of the country. Integration of operations is aided materially by regular circulation of engineering reports of the types discussed above.

A new situation may arise, however, which cannot be handled even with such a highly efficient system. One of the plants produces an alloyed steel that is sold to a small independent company equipped with special processing facilities. This company puts out high-grade automotive parts that find a ready market, but its capital has been stretched thin. In fact, if it cannot obtain raw materials more cheaply, it may go out of business. The alloy metal being its biggest raw-material item, the top executives of Company C have a difficult problem: either reduce the price or stop shipment. Company C would not be affected disastrously by the loss of this market, but it cannot profitably sell for less.

For some time, Company C has considered moving into the alloy automotive parts field, so the directors conceive the idea of supplying sufficient capital to obtain a controlling interest in the processing plant or to purchase it outright. A decision must be reached within three months.

Company C's interest in the processing plant must not become generally known because competitive bidding would decrease the economic attractiveness of the proposition. First, all available technical, marketing and cost data relating to the alloy are gathered from within the company: It soon becomes apparent that additional information is necessary, so the available data are quickly collected by division heads and put into the form of a special report. Still the market situation is not clear.

An independent research organization that specializes in market analysis is engaged to complete the investigation. Within six weeks a special report analyzing the present and future markets for the alloy is received and combined with the

**Survey reports place before the governing board the results of exhaustive studies made by key personnel and/or specialists. The data usually pertain to subjects that have a significant bearing on decisions concerning major company policies.**

other special report. Filled with all the pertinent data compiled by experts from within and outside the company, the composite survey report given to the board of directors represents the best available and reliable picture of the entire problem. The board is then able to reach a final decision.

### *Making Reports Interesting*

If the author of an engineering report can catch the reader's imagination in quick-moving, single-sentence opening paragraphs, he is well on the way toward obtaining careful reading to the last page. Having made a good start, he maintains reader interest by varying sentence length, style and structure. Few sentences should contain more than 40 words, and conversely, too many short, choppy sentences should be avoided.

The overall objective is to strike a balance between breeziness and stuffy dignity. Such a balance is assured if a report has: (1) Easy readability; (2) simplicity; (3) clarity of expression; (4) forcefulness; (5) directness; and (6) conciseness with completeness.

Frequent but suitable headings contribute to readability. Graphical presentation through simple photographs, charts, drawings and short tables add a great deal of "eye appeal" to a report. Sometimes complex mathematical analyses can be replaced or supplemented by simple figures, resulting in a clearer understanding of the facts. Clarity in writing makes the text easy to follow and reduces the possibility of misinterpretation. Likewise, active verbs help to create sharply defined thought pictures.

One main point that should be borne in mind: The report must tell a concise, complete, clearcut story. Writing a whole page where one sentence will do is poor writing. If confused, the reader loses interest.

### *Consider the Reader*

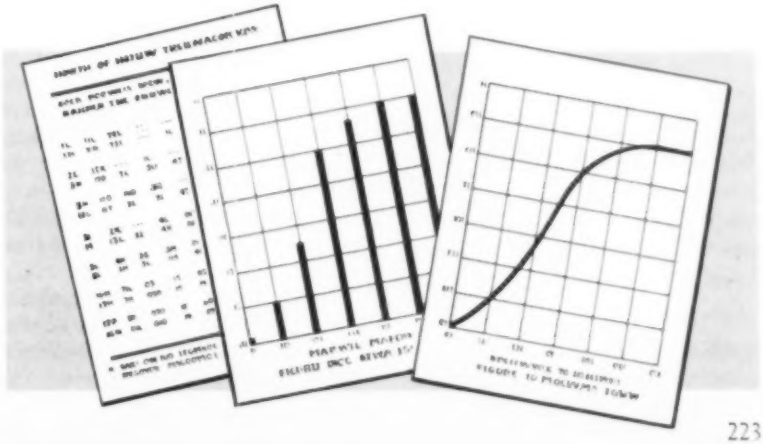
Will the report be used by technical people only, or by both technical and non-technical? Non-technical people may be awed by pages of formulas and theoretical calculations, but they may lose track of the main theme if they are forced to wade through unfamiliar expressions. When a report is read by technical people only, it should contain technical language. There is, however, a limit because even the technically trained mind can be "fogged" when saturated with scientific terms. Fogginess is increased by using words like *gradient, interrogate, maximum* or *optimum* instead of *slope, ask, most* or *best*.

Technically trained people and others will enjoy reading a report that is easy for them to understand. Occasionally, a reader will be willing to puzzle out complexly worded sentences, but even so, it is not certain that he will get the real idea being expressed.

Planned orderliness and logical sequence of ideas are also important. Other virtues of a good report include uniformity in style; and an objective, impartial and temperate approach on the part of the writer.

While top management in general is becoming more aware of the value of internal communications among top executives, department heads and engineers, engineering executives will continue to use technical reports in planning and conducting their operations. By intelligent use of such reports, the full value of company "know-how" can be realized and technical decisions made expeditiously.

**Statistical data can be left in the original tabular form or converted to one of several types of graphical plots. The choice of presentation depends upon the type of report involved and the level of technical understanding of the readers.**



# EXECUTIVE OPINION: The Key is Personnel

*Executive engineers are today plagued with many problems not directly associated with the technology of design and development of products. To obtain background and briefing on these problems* PRODUCT ENGINEERING *has during the last twelve months sponsored executive engineering forums, one with the Mechanical Engineering faculty of New York University.*

*These forums were participated in by top engineering executives from a large cross section of industry. The geographic locations of the industries represented are widely separated. The views and comments of these engineers as summarizd in the following report, therefore, can be taken as representative of those of executive engineers throughout industry.*

## Status of the Profession

TO GET MORE YOUNG MEN INTERESTED in an engineering career, it was emphasized that industry must strive to educate students at the junior and senior high school levels on the advantages and rewards on an engineering education, the objective being to divert more high-caliber students into the study of engineering. A step in this direction is to make the public in general aware of the engineer's contributions to society. Improvement in the welfare of society comes in great part from the creative work of engineers. When proper prestige is accorded the engineer, it will have great influence in guiding young men toward the study of engineering.

Members of the forums agreed that one great deterrent to the choice of engineering as a profession was the popular erroneous belief that engineers are chained to drafting boards. Numerous instances were cited of men who started their careers in the drafting room and then advanced to top executive positions.

As an argument against there being any chains that hold a man to the board, one forum member observed that in his work he has kept the board chained to him. He has done so, because work over a board can be developed into a very useful method of thinking, and one whereby one's own thoughts can be transferred to others more easily. His further comment was: "The board is never a deterrent to a good man; only those who are incapable of rising above pencil pushing are chained."

Engineers participating in the forums do not expect the demand of industry to decrease. One member

reported for his company that twice as many engineering hours per man shop hour are now required as compared with that of twenty years ago. Reasons for this increase are: The fund of engineering knowledge has been growing steadily; the complexity of engineering designs has been on the increase; and shop production efficiency has increased.

## Sources of Talent

IN ADDITION to the present practice of sending representatives from industrial personnel departments to visit colleges for the purpose of screening students, selling the company, and offering jobs, suggestions put forth at the forums for other methods of overcoming the present shortage of graduate engineers included:

A. Employ men who have dropped out of engineering schools before graduation. These men are partially trained in engineering and can be started as draftsmen at a level slightly lower than that at which graduates are started. Only about 35 to 50 percent of undergraduates finish their courses.

B. Make use of cooperative educational plans. Companies who use cooperative students usually keep one-half of them in their employ after graduation.

C. Institute a program of scholarship awards for local high school students to take cooperative training in the home plant. With such a plan, men will be obtained who will want to stay near home.

D. Bring into the drafting room the shop apprentices who show some aptitude and interest for engineering. Send these men to company schools or to outside evening schools for special training.

E. Send the older graduates in the company to their schools at graduating time to talk with their former professors and friends about available graduates, search these out and talk with them.

## Training New Employees

INDUSTRY IN GENERAL is convinced that college graduates are short on fundamentals, have no design experience and no drafting ability. It was also pointed out that many men who had taken up engineering should not have done so. Hence the newly employed graduate must go through a period of training. At the very start of their employment, however, they should be given work that entails some responsibility.

To orient and train newly employed engineering graduates, and to provide opportunities for further education to older employees, many plans were reported to be in operation. Chief among these were:

A. Lecture courses held after working hours are offered for the instruction of draftsmen. Attendance is voluntary. Lectures are open not only to members of the engineering department but also to employees from other departments of the company. About fifty percent of the engineering employees who might benefit from the courses attend.

B. Lectures on new projects. These lectures are planned by the chief engineer and are given during working hours. Attendance is entirely voluntary and runs from 30 to 100. Lectures cover such subjects as new contracts and new developments taking place in the engineering department.

C. Junior engineers sit in on all engineering conferences.

D. Send out junior engineers along with senior engineers to investigate the operation of equipment in service. Whenever a product gives trouble in service a new engineer who has worked on the project is sent along with an experienced field engineer to go into the field and investigate.

E. Encourage men to pursue further study. On a selected basis, some companies pay all or half the cost for outside courses taken by their engineers. The studies must be in the field in which the engineer works.

F. Encourage membership in engineering societies. About two-thirds of the companies represented at the meetings pay the cost of their engineers attending the meetings of "recognized" societies. About one-third expect their engineers to belong to one society and to pay his own dues in that society; these companies pay the dues for all additional memberships that are approved by the company. A few companies encourage their engineers to seek membership on society committees.

One company who pays the dues and costs of their engineers to attend society meetings, estimates that their top bracket engineers put in from six to eight weeks per year of their time on engineering meetings, preparing papers, serving on committee meetings and similar nonproductive activities. This company, however, stresses that if an engineer does not engage in these activities he is not worthy of his job.

G. Encourage engineers to increase their prestige. Some companies pay a specified sum per page of space for articles that their engineers have published in recognized periodicals and magazines.

H. Start men in experimental test work, then channel those who have design inclinations toward design work. Many companies are convinced that this is the best avenue for ultimate achievement of the top engineering executive jobs.

I. Employ a college professor to train college graduates on a two year student training course basis. This arrangement, however, has been supplanted by an intensive student training course, which requires three months in the various engineering departments including testing and design. During this course, the design and the salesman types of engineer are segregated.

J. Put high school graduates through an intensive training course which

covers a range of specialized engineering. During the course, management impresses the students that it is extremely interested in their welfare.

K. Start college graduates on the drafting board so that they may learn how to handle engineering drawings.

L. Start the college graduate on engineering department operations such as heat transfer problems and design calculations.

M. Start the college graduate as a junior designer. He may have some drafting to do but he is distinguished from the draftsman as the fellow that does nothing but drafting.

N. A two-year program of elementary conditioning in which student engineers (college graduates) go through a progressive training program that includes academic work as well as actual productive engineering. On completion of the program, the embryo engineer selects one of two job choices: (1) Design and development; or (2) Supervising.

## Advancements and Promotions

MOST COMPANIES prefer to promote their engineers up through the drafting room. But when following this procedure, the companies must continually combat the mistaken idea that a draftsman has little chance for advancement.

Among the company practices reported concerning methods in force for advancing and promoting young engineers the following are typical:

1. New engineering department employee generally receives advances in salary until he has reached the position of assistant project engineer. Reviews are made at regular intervals and men doing acceptable work are given a raise in salary. It usually takes five years after he comes with the company for a man to reach the position of assistant project engineer; particularly brilliant men make the grade sooner. After reaching the position of assistant project engineer further promotion is on a competitive basis.

2. Merit increases in salary are given in recognition of inventiveness.

3. Designers may get more salary than their supervisors. Often an able designer who has no inclination toward administrative work is of more value to the company than his supervisor and is paid accordingly. To avoid strained personnel relations when a designer reaches the point where his pay equals that of his supervisor, in one company he is moved out of the department and placed directly under the vice president in charge of engineering.

## Bonuses and Patents

INCENTIVE BONUS PLANS have been put in force by some companies. One reports that only the top executives participate in the bonus awards; the men in the engineering department are rewarded only with salary raises.

A similar arrangement exists in another company except that the bonus is shared in by all men who receive a salary per month that exceeds a specified amount. The bonus is based on the profits of the company. To offset non-participation in the bonus plan, overtime is paid to those who are not included in the plan. Overtime rates range from nothing up to one and a half times base pay and are approximately in inverse ratio to the salary received.

One company immediately pays $25 for any patent disclosure that appears to be desirable and patentable; when the patent is issued an additional $75 is paid to the employee. If the company uses the patent in their product, no royalty is paid to the inventor. If the company licenses an outside manufacturer to incorporate the patented device in his product, the inventor is given a percentage of the licensee's payment. The patent may cover only a small item in the licensing agreement but the inventor receives a proportional amount of the license payments. If the patent does not concern the product of the company, the company may give the patent rights to the man who made the invention.

To encourage inventiveness, one company not only pays $100 minimum for any patentable inventions made by their engineering department employees, but also distributes annually a brochure publicizing the inventors and their patents.

Another company pays one dollar for inventions offered for patenting, $25 when the patent is applied for, and an additional $100 when the patent is issued.

From 25 to 50 percent of the royalties received from patents are distributed by one company to the employee who is responsible for the invention. The inventor, however, is paid only one dollar if the patent is associated with a product that the company has been commissioned to develop.

A nominal fee for patent rights is paid by one company, but designers and engineers get the prestige of holding the patent. Occasionally, a number of men work on a project and all are recognized as co-inventors in their assignment of patent to the company.

Individual engineers are not honored for their inventiveness by one company for two reasons: (1) When one man is given preferential treatment for a unique design, it has been found that many men will keep their ideas to themselves thus blocking cooperative effort and spoiling team work; and (2) Often it is difficult to assign a patent that results from the associated efforts of several men.

The responsibility for the successful operation of the patent reward system, in one company, is vested in the vice president in charge of engineering and the patent board. The patent board, which includes the president of the company and the responsible heads of engineering, manufacturing and sales departments, reviews all the patent disclosures submitted, and decides which are acceptable. On acceptance by the board of a disclosure, the engineer who submitted it receives $30; on issuance of the patent he receives an additional $60 reward.

# TECHNICAL NEWS

GERMAN TWO-DOOR CONVERTIBLE OPEL SEDAN is now in production again.

## Research and Development Programs Rebuild Germany's Position in Industrial Markets

*FRANKFORT*—Carefully integrated programs for research and development on the academic and industrial levels are helping Germany to regain its position in commercial markets throughout the world. Outstanding new designs of many products are out of the drawing-board stage. But release and production of these has been held up pending the signing of a treaty between the Allies and Germany, and the expiration of the Allied Military Security Board.

On the academic level, the Max Planck Society for the Promotion of Science is the successor organization of the defunct Kaiser Wilhelm Institute. Head of the present organization is Prof. Dr. Otto von Hahn. The society was founded February 1948 in Goettingen and at first included only the 26 institutes in the British and American zones of occupation. In November 1949, the former Kaiser Wilhelm Institutes in the French zone were incorporated into Max Planck. No contact exists at present with the institutes in the Soviet zone of Germany. Individual institutes now part of the "Research Group Dahlem" and the "German Research Institute" in Berlin are scheduled to join Max Planck in the near future.

The final liquidation of the Kaiser Wilhelm Institute and the transfer of its assets to Max Planck was agreed upon in April 1951. Aims and principles of Max Planck are the same as those of the Institute. The directors of the 35 Max Plank Institutes operate under conditions of complete academic freedom and are not limited in either choice or method of execution of their scientific work.

In 1949 the eleven "Laender" of the Federal Republic agreed on a method of joint financial support for Max Planck. For the budget year 1952, the Minister for Finance of the Laender have voted a total of DM 15 million for the institutes.

Germany now has seven technological institutes, located at Aachen, Braunschweig, Hanover, Darmstadt, Karlsruhe, Stuttgart and Munich. Each school has an enrollment of between 3,000 and 5,000 students. Main emphasis seems to be on civil engineering; probably because the physical reconstruction of Germany's cities and plants has been the most urgent post-war task. Rectors of the schools agree that standards are again as high as they were prior to 1933. Greatest problem is that of financial support; most schools operate under extremely tight financial conditions and often cannot buy either textbooks or equipment they need.

Leading German companies have actively re-established their own research and development departments. They realize they were cut off from outside contacts for the better part of a decade and must now get out and hustle if they want to catch up, especially in the overseas market.

German engineering design has thus far been along fairly conventional lines. The shortage of steel, fuel and other raw materials has put some pressure toward the use of material-saving designs. But this does not appear to be a permanent trend; rather one dictated by economic pressures. Emphasis is put on "quality" and low prices all along the line, especially on export products.

German design activity is presently not concentrated on any one special sector. There is such a tremendous demand for all types of products from typewriters to locomotives, from machine tools to railroad equipment and passenger cars, that engineering design cannot remain concentrated along one line. The Germans are putting out good products in almost every line. For example, the Olympia typewriter compares favorably with American portables. At the same time, it looks very much as if some German machine tools have a chance of "selling" themselves to U. S. industry. Some repeat orders, even after the present boom expires, are expected by German manufacturers. But machine tools in the automotive field are still largely of U. S. make.

The consensus of German engineers and businessmen is that no German products are "specially designed for the export market." The products which sell well domestically, are usually of such quality and design that they sell abroad. A typical example is the German Volkswagen (people's car) which, with its air-cooled motor finds a ready market not only in Germany and Europe, but in Asia, Africa and South America, as well. In other fields, like optics, it is German reputation for quality that sells the product, rather than a special "design for export."

Queries on German scientific and technological work in areas not now receiving much attention in the U. S. are answered in a most non-committal fashion. This probably indicates that the Germans are working on some unusual specialties. But recent cases of industrial espionage have caused many German firms to become very reserved and careful when answering queries of this type.

A new "Activ-Steuer" or active rudder for ships of all sizes has been designed by the firm of Preusger & Co. This rudder allows ships to turn on their own axis, and has military implications of some importance. Production plans are finished, but actual

producing, it is said, will not start until the contractual agreement between Germany and the Allies is signed and the Allied Military Security Board has expired.

Along the same lines, a new and revolutionary system of fuel injection for ship's diesel engines is supposed to have been designed. The new method is said to double the power and capacity of diesels. The new engines are to be made by Daimler at Mannheim, after the Military Security Board has ceased to exist. Engineers also hinted that new methods of saving weight in ship construction were being developed. But no further details are available.

The only organization which can now properly be called Krupp of Essen is a locomotive works employing about 2,000 men. The firm is working on export orders for Pakistan, India and several South American countries. The balance of the huge Krupp concern has been decarterlized and is now working on an independent-company basis. The coal holdings of Krupp work under the Allied Coal Control Group.

Opel, General Motors, are concentrating on passenger cars (the Olympia) and trucks. No startling developments are reported, other than the fact that the new Opel Olympia need no longer be "broken in" but can be driven at maximum speeds from the day the car leaves the plant.

At Allgemeine Elektrizitaets-Gesellschaft, the design activity is spread over a tremendous range of products. Just about everything that is electric.

The Society of German Engineers (VDI) again exists in pretty much its prewar form. Present membership is around 28,000. Headquarters of the society are in Duesseldorf, where the society owns its own publishing house. They publish a newsletter as well as a monthly magazine. Address is: Deutscher Ingenieru Verlag, Duesseldorf, Prinz George Str. 77.

**ENGINEERS AT THE NACA LEWIS FLIGHT PROPULSION LAB use this servo board to lay out special instruments that they design. Made of metal, 3 ft wide by 4½ ft long, the table has holes spaced at one inch intervals. To use the device, the engineer assembles the components of the instrument around the table. By trial and error, he fits the parts together, securing them by bolts, through the table top. The completed instrument is then measured to see if it meets the specified dimensional limits. The lab claims that the servo board has saved many hours of instrument design**

## Aero Medical Association Hears Design Suggestions To Reduce Crash Deaths

WHAT DESIGN FEATURES would increase the chance of passenger survival in case of an airplane crash? Dr. Edward J. Baldes of the Mayo Clinic and James J. Ryan of General Mills Aeronautical Research Laboratory studied this problem and reported in general terms to the annual meeting of the Aero Medical Association.

They found that impact was a frequent killer and made these recommendations to reduce it: The forward one-third of the fuselage should be designed to absorb the energy of an impact crash. This construction should be so strong that the deceleration caused by the impact will be less than the maximum that humans can tolerate.

The researchers also urged engineers to make the under portion of the fuselage flexible enough to absorb the impact of a forced belly landing; and to consider the use of parachutes from the airplane's tail to lessen impact.

They concluded that seats are the most important factor inside the plane. They should face backward if present seatbelts are used. If the seats face forward, a new seatbelt and harness should be designed to connect to vertical supports that are integral parts of the fuselage's tubular structure.

With these design features integrated into the airplane, the next step for decreased crash fatalities is proper fire protection.

Baldes and Ryan also recommended that every airplane should carry a set of instruments in its tail so that events leading up to a crash can be reconstructed by investigators. They claim that under present conditions, there is often no evidence left to separate the human, mechanical and natural factors in an air disaster.

## Details of Coal-Burning Locomotive Gas Turbine Revealed at American Power Conference

John I. Yellott and Peter R. Broadley of Bituminous Coal Research Inc. reported to the American Power Conference that they had completed preliminary testing of a 4,250 hp coal-burning locomotive-type gas turbine power plant. Results of the tests indicate that minor modifications would make such a power plant competitive with oil-burning turbines.

The researchers used a six-stage re-

ion turbine designed to operate at 700 rpm and a maximum inlet temperature of 1,300 F. A 21-stage axial compressor is coupled at its intake end to the turbine shaft, while the discharge end of the rotor drives the four main generators through a reduction gear. Three auxiliary generators are mounted above the main generators and driven by secondary gears. Turbine and compressor shafts are supported by three sleeve bearings.

An oil pump driven through the reduction gear supplies lubricant. But during stopping and starting periods a small d-c motor-driven auxiliary pump takes over. Heat picked up by the oil is dissipated by an air-swept oil cooler. The turbine uses a regenerator installed immediately above the turbine exhaust so that the weight and end thrust are taken up by steel supporting frames. A bellows-type expansion joint provides the necessary flexibility between the turbine and regenerator.

Since the unit burns solid fuel, it needs an ash separator. This consists mainly of 26 ten-inch diameter Dunlab tubes mounted in parallel. Ash is discharged continuously through a tangential blow-down line to prevent incandescent particles from sintering and plugging the separation equipment.

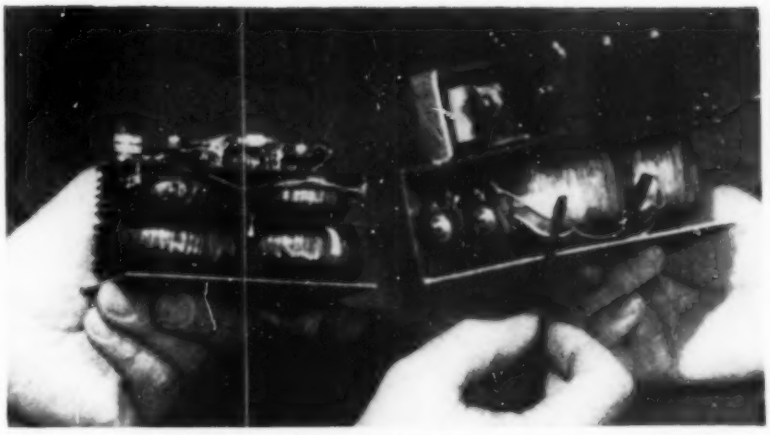
For combustion, twin film-cooled combustors are used with concentric dual-fuel burners. And the main coal burner surrounds the auxiliary oil burner. Oil igniters mounted on the head of the combustors accomplish ignition.

The power plant is designed to use regular locomotive-run-of-mine coal that needs drying and pulverizing.

After evaluation tests were run using oil, the plant was operated for 178 hr on high volatile bituminous coal. Combustion efficiency as determined by ash analysis was consistently above 95 percent. At full load, 4,400 hp output, turbines efficiency was 87.5 percent; compressor efficiency was 84.0 percent; and regenerator effectiveness was 55 percent. The unit operated as well with coal as it did with oil and, casual observers were unable to tell whether the plant was burning oil or coal.

Minor mechanical difficulties were encountered including hot air leakage at the turbine inlets and rubs of increasing severity. These have been corrected for future tests. When the turbine was dismantled, internal inspection revealed no deposits or erosion on the blades.

The power plant is undergoing a 750 hr high-temperature, high load test to evaluate the improvements.



TWO OF NOL'S NEW MAGNETIC AMPLIFIERS. One on the left is for 400 cycle duty; one on the right is for a 60 cycle system. Both operate on 115 v. Half-wave operation cuts size to 50 percent of conventional magnetic amplifiers.

## NOL Magnetic Amplifier Uses Half-Wave Circuitry

A NEW MAGNETIC AMPLIFIER using a circuit based on half-wave operation has been developed in the Magnetics Division of the Naval Ordnance Laboratory at White Oak, Md. The device looks particularly promising for use in instrument type servos where it exceeds the performance of conventional magnetic amplifiers by a factor of 2 to 5.

This circuit may be adapted for use at any power frequency including 60 cycle, for which other magnetic amplifiers are frequently too slow in response. In 400 cycle servo systems, the new amplifiers have matched in many respects the performance of vacuum tube units. However they do not need filament power supplies. In addition they have low maintenance and replacement costs, and are highly reliable.

During the development, studies showed that half-wave circuitry should have a delay of no more than one cycle of the power frequency instead of the four to 50 cycle delay found in conventional magnetic amplifier circuits. And experiments confirmed this. By decreasing the amplifier response time, the scientists overcame some of the serious difficulties of using magnetic amplifiers in servos. Instability was one such problem.

The new amplifier circuit is two stage. And it is possible to go from the first to the second stage without going through a passive network. Voltage control rather than current control is used in the second stage. By direct coupling of stages and voltage control, the control windings have been reduced from around 2,000 to 5,000 to only 3 to 20 turns.

In this circuit, two cores per stage replace the four cores needed in conventional circuits. This reduces the size of the amplifier to half that of conventional amplifier circuits.

## Army QMC Develops Fast Working Temperature Indicators

PAPER THERMAL INDICATORS capable of instantly determining temperatures from 115 to 500 F have been developed by the Army Quartermaster Corps. QMC designed the indicators initially to measure thermal radiation from atomic blasts, and found them useful in testing the performance of gasoline engines, motors, heaters, and other appliances.

Inexpensive and readily disposable, the new indicators consist of white pigment coatings on black paper. Each coating is designed to melt at a definite temperature. At the proper temperature, the white coating melts and disappears into the black porous paper. The change from white to black is not reversible and constitutes a permanent record of the temperature.

Advantages of these indicating devices include instantaneous reporting of a definite temperature. Also they may be used by color-blind persons and are made from materials that are readily available. Testing was done at the Research and Development laboratories of the Philadelphia Quartermaster Corps Depot.

## Ceramic Thickness Gage Permits Accurate Determinations

THICKNESS OF CERAMIC COATINGS applied to non-magnetic materials can be measured within 0.0005 in. accuracy by a new instrument built at the Ryan Development Lab. Designed by the National Bureau of Standards, the new device permits nondestructive determination and can be used with curved surfaces as well as flat areas.

Operation of the device depends on the change in inductance of a coil when it is brought in proximity to a metal surface. The metal acts as a short circuiting device that critically affects the coil's inductance over short distances. Presence of the ceramic material has no appreciable effect on the field at the frequency used.

The instrument consists of two parts: A plastic test head in which an electromagnetic probe coil is embedded and an inductance balance indicator which utilizes a galvanometer. Protruding through the coil is a slender plastic rod that is attached to a dial indicator gage. This rod is free to move axially and its displacement is indicated by the gage. The inductance balance unit incorporates an impedance bridge that can be adjusted by potentiometers to bring the galvanometer to zero reading when electrical balance is attained.

In testing coatings, the first step is to calibrate the instrument with an uncoated sample of the same metal as that which is ceramic coated. The probe coil is placed against the metal surface with the plastic feeler rod in contact. The dial indicator is set to read "zero." The current is turned on and the inductance of the coil is established as a reference by adjusting the bridge until the galvanometer also reads "zero."

The coil is then transferred to the surface of the ceramic coated part. Its distance is adjusted until the galvanometer reads "zero." This will occur when the coil is the same distance from the conductive metal as it was when the calibration was made. At this point, the feeler rod is displaced an amount equal to the coating thickness.

## Foreign Machines Dominate Tool Exposition

FOREIGN MACHINE TOOLS dominated the Industrial Exposition held in conjunction with the Annual Meeting of the American Society of Tool Engineers in Chicago. Largest exhibitor in the show was the Cosa Corporation which displayed over 40 foreign machines. Interest in these machines was sharpened by the continuing long deliveries in American machine tools.

German and Swiss units made the biggest impression on industry observers. The Swiss made Dixi Horizontal Jig Borer guarantees an over-all accuracy of 0.0002 in. for all operations. In this machine all coordinate dimensions are set by large dials and adjusted with the aid of optical microscopes.

Several Peter Walters' tools, German manufacture, were on display. One, a vertical honing machine, operates with a cast iron lop and a special abrasive. Tool diameter is adjustable in increments of 0.0001 millimeter. Another Wolters machine displayed was a two plate rotary lopping machine. Both plates are power driven. The upper plate can swing completely out of the way to permit the lower to be used as a plain flat lop.

The Sensitat Universal Lathe, by Heid, Vienna, incorporates an unusual electromagnetic tracer following drive capable of direct in and out feed. Ways are not hardened, but are of the inverted vee type and are filled with oil at all times. Lead screw and rack are inside the bed which is covered by a telescopic steel plate. The tailstock and steadyrest operate on a separate set of ways disposed vertically at the back of the machine.

One French machine that attracted considerable interest was an engine lathe with a hydraulic copying attachment. Designed for carbolic tooling it has speeds from 30 to 2,000 rpm. Clutch and brake are foot operated, leaving both hands of the operator free. The copying attachment permits the use of both front and rear tools.

Other foreign built units that were displayed came from Great Britain, Canada, Denmark, Belgium, and Italy. Displays by American manufacturers indicated a trend toward more automatic production equipment to supplant dependence on human variables.

The Tool Engineers' meeting was highlighted by the presentation of the largest number of technical papers in the society's history.

## NBS Reports New Data on Ductile Cast Iron

STUDIES MADE BY the National Bureau of Standards indicate that adding certain materials to iron has a negligible effect in forming nodular graphite. While both cerium and magnesium have been used successfully to produce the nodular structure responsible for the ductility and superior strength of nodular cast iron, NBS researchers tried adding magnesite, iron sulphide, calcium, nickel-chromium-molybdenum, and boron. Besides the different additives, the investigation considered such variables as composition, melting and pouring temperatures, and cooling rate.

In this study, completely nodular

graphite was obtained only in iron containing magnesium in excess of 0.03 percent. The researchers observed two types of nodules, radial and structureless. And, the structureless types frequently had a crystalline core. Results with magnesite, magnesia, and the other additives were essentially negative. Oval or irregular patches of graphite, not true nodules were observed in iron treated with magnesia iron sulphide, and boron. Only a few nodules were observed in calcium-treated specimens, but this was probably because of the rather small amount of calcium retained; other investigators have reported 100 percent nodular graphite structures in irons having calcium contents higher than were obtained in this investigation.

Initial experiments with magnesium as the nodulizing agent used commercially pure magnesium. However, the violence of the reaction between pure magnesium and molten iron made close control of these early melts difficult. The scientists abandoned this method of addition and added the magnesium in 80 Cu—20 Mg alloy.

They determined the effect of cooling rate on microstructure by casting wedge-shaped bars. The cooling rate, greatest near the apex of the wedge, was observed at intervals along the bar by means of thermocouples.

## Low-Boiling-Point Lacquer Thinners Improve Auto Finishes

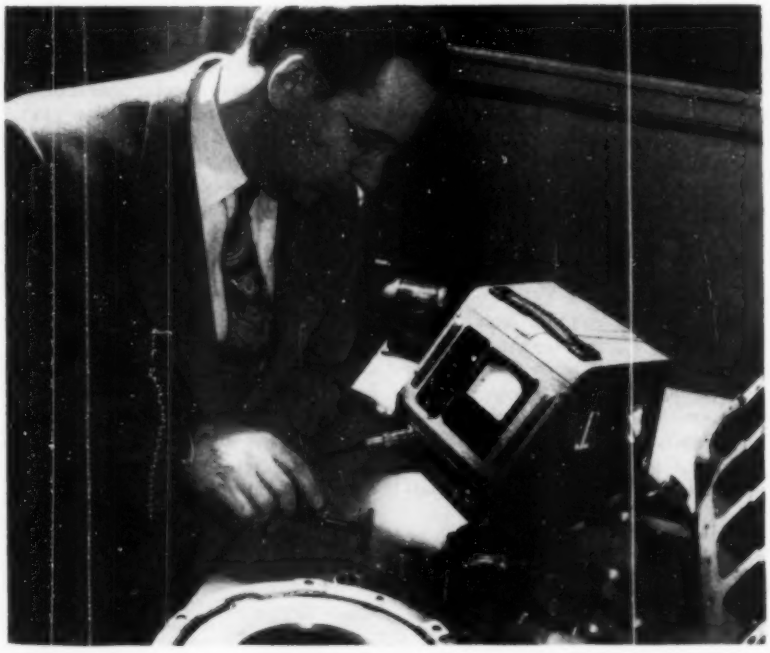
GENERAL MOTORS RESEARCH LABORATORIES applied a new concept to lacquer thinners and improved the technique and results of applying lacquer to automobile bodies.

In the past, thinners have been formulated so that both the solvent and the diluent evaporate at the same rate. (The diluent is used only to help reduce viscosity). As a result, both were present throughout the time the lacquer set and dried.

GM scientists deviated from the idea and developed a lacquer in which the diluent portion of the thinner had a low-boiling point. All of it evaporated between the time the lacquer left the spray gun and the instant it hit the car body. The solvent portion of the thinner had a higher boiling point so that, while drying, the lacquer film on the body had a tendency to flow slightly.

The new thinner does away with the tendency of the finish to "orange-peel," the formation of surface which has a porous roughness like that of an orange peel. Formerly orange peel had to be removed by time-consuming surface polishing.

While it requires a different technique and adequate drying facilities, the new lacquer improves the surface smoothness, requires less polishing, and fewer coats of lacquer. Costs of special training given to operators is said to be more than offset by savings in getting rid of polishing operations.



**NEW SURFAGAGE for measuring the "roughness" of precision parts was described to engineers at the ASTE Annual Meeting by General Motors Research Laboratories' engineers. Capable of detecting a scratch as small as one millionth of an inch, this portable instrument uses a vacuum tube 5/16 in. in diameter and one inch long as its main element. Elements in the tube can be moved relative to each other causing rapid voltage changes. Movement is produced by a diamond stylus drawn by hand across the surface to be checked and connected to the tube through a liquid of high viscosity.**

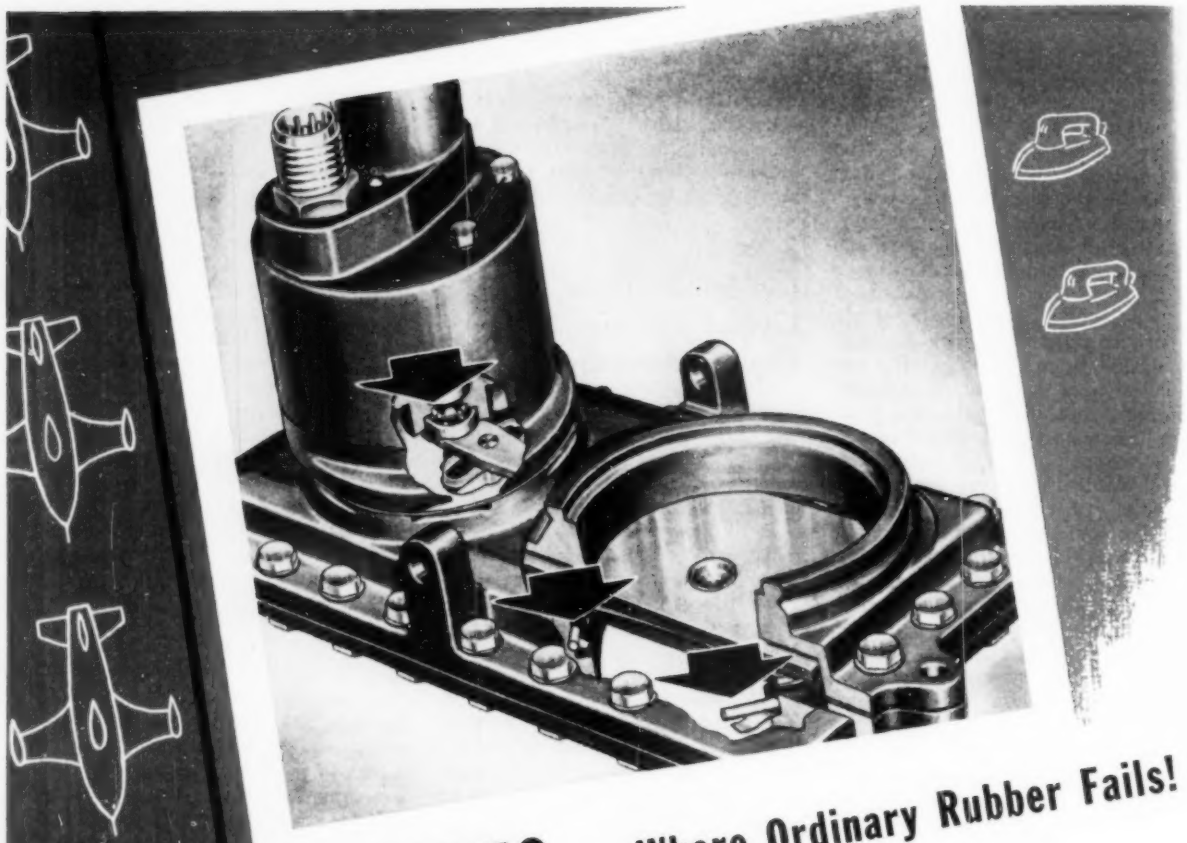
MOLLERIZING IRON AND STEEL gives the metal all of the properties of aluminum except weight, practically at galvanizing costs according to the American Mollerizing Co. And the coating resists atmosphere corrosion better than galvanizing. To coat steel with aluminum, the process uses a standard electric salt bath furnace with molten aluminum floating on molten salt. The steel is dipped through the aluminum until it reaches the temperature of the salt and then it is slowly withdrawn. D-c current fed to the aluminum aids the bonding process. Low carbon steel is the easiest metal to coat; cast iron, high carbon steels and certain other alloys cannot be mollerized with this method.

•

ON APRIL 1ST, the American Electroplaters' Society moved its offices from Jenkintown, Pa. to the American Bldg., 445 Broad St., Newark 2, N. J. Editorial and business offices of the Society's journal "Plating" have also been moved to Newark.

•

COMPRESSED PURIFIED AIR with an oxygen content of only 16 percent by volume is the secret of the Flame Seeper, an Egyptian fire fighting invention. The inventors claim that the air will blow out any kind of fire without damaging the burning material. Components of the device include an air compressor with oxygen absorber driven by a small kerosene engine and a cylinder for storing air. Tests are planned in Paris, France.



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# Determining Rotor Inertias By the Pendulum Method

D. K. WRIGHT, JR.
Case Institute of Technology

Rotational inertia is important in calculating the acceleration time and braking requirements of many machines. One simple experimental way to find the $WR^2$ of a rotor is by means of the pendulum method. Here, the rotor remains in its frame and is suspended by the bearings. A pendulum is attached to the shaft and is set into motion. The assembly is made to swing with an amplitude sufficiently large to permit the timing of at least 15 or preferably 25 complete swings; this range is necessary to reduce the effects of timing inaccuracy. A large starting angle is often required to give enough energy to overcome the damping caused by bearing friction.

Large angles of swing do not follow the laws of simple harmonic motion. Consequently, it is necessary to convert the experimentally determined period $P_a$ of the swing to an equivalent simple harmonic period $P_o$ by the relation:

$$P_o = M \times P_a \qquad (1)$$

The conversion factor $M$ is obtained from Fig. 2. These curves are based on the deviation averaged over the range between the angle at the beginning ($a_1$) and at the end ($a_2$) of the timing period. See Fig. 1(A).

Values $P_o$ or $P_a$ from several trials are averaged to get the period $P$ which is used in the equation:

$$\text{Rotor } WR^2 = 0.815\, wLP^2 - wr^2 \quad \text{(lb. ft}^2\text{)} \qquad (2)$$

Where $w$ is the weight of the pendulum in lb. and $L$ the distance in feet from the center of shaft to pendulum c.g.

The right-hand term, $wr^2$ is the pendulum inertia and can also be experimentally found by suspending it on a knife-edge through the collar bore and swinging it to find its period $p$ as shown in Fig. 1(B). This period $p$ is used in the equation:

$$wr^2 = w(0.815\, lp^2 - l^2 + l^2) \qquad (3)$$

Where $l$ is the length (in ft.) of the pendulum suspended alone on the knife edge.

Example:

A 7.75 lb. pendulum has a $wr^2$ of 11.3 lb. ft$^2$ and $L$ of 1.10 ft. It is mounted on a rotor and swung from $a_1 = 62°$ to $a_2 = 10°$. The average period $P_a$ is found to be 2.10 sec. Using Fig. 2, M is found to be 0.971 and Eq (1) gives:

$$P = 0.971 \times 2.10 = 2.04 \text{ sec}$$

From Eq (2), Rotor $WR^2$ =

$$0.815 \times 7.75 \times (2.04)^2 - (11.3)^2$$
$$= 17.6 \text{ lb. ft.}^2$$

Damping encountered as the result of bearing friction and windage does not significantly affect the frequency of oscillation. In cases where at least 25 cycles are used and the pendulum $wr^2$ is not more than that of the test part, careful work should yield results with an error of less than 2 percent.

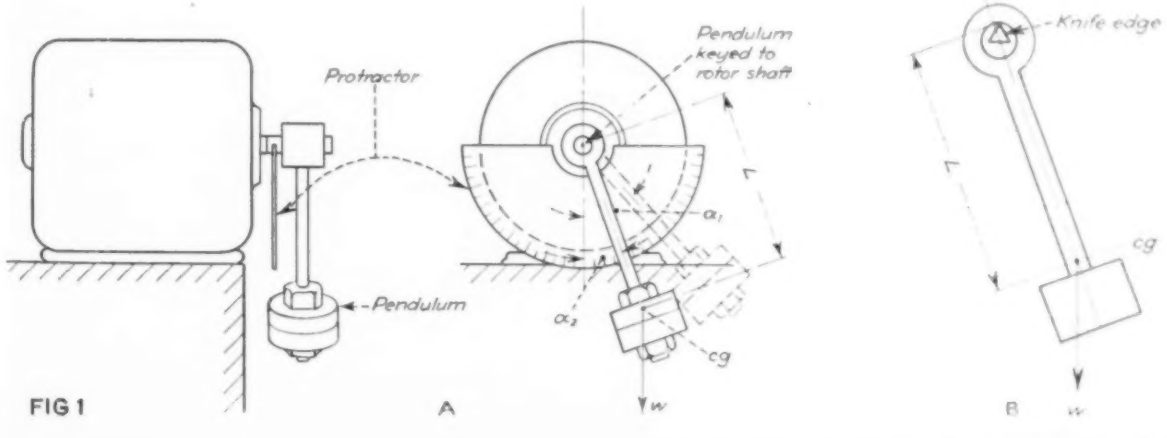


FIG 1

(Continued on page 235)

# You're always right with AUTO-LITE Die Castings

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# Determining Rotor Inertias by the Pendulum Method (continued)

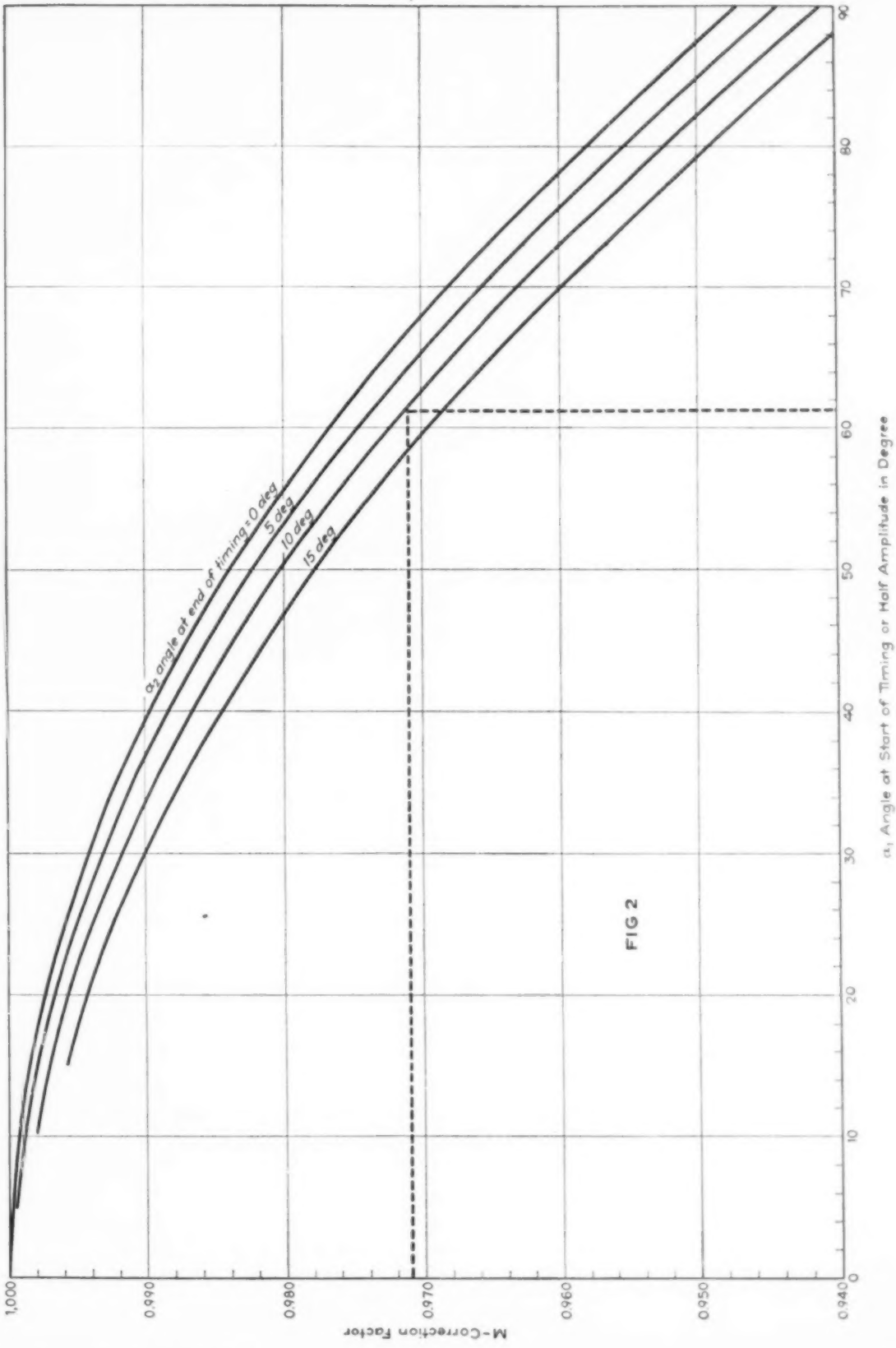
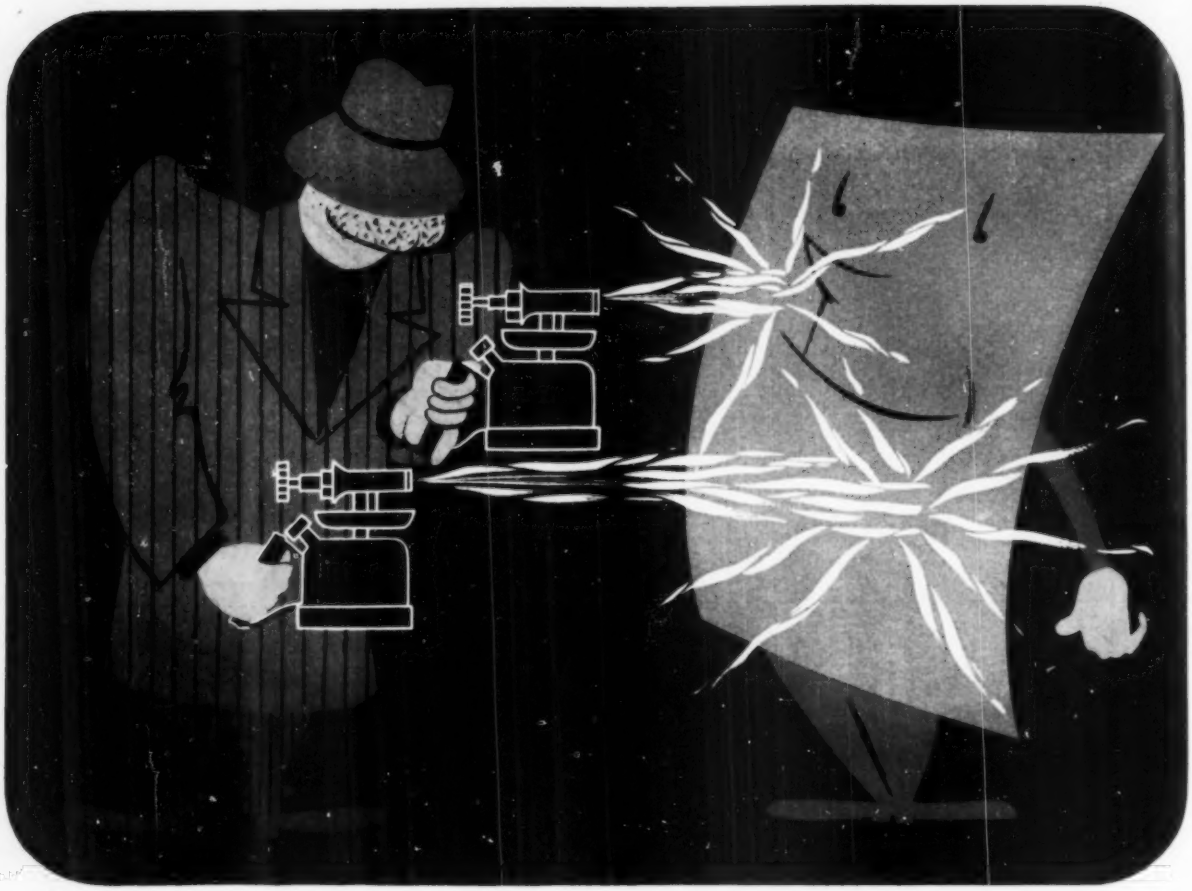



FIG 2



# Here's a steel that gives heat the "BOUNCE-OFF"

Yes, heat *bounces off* the surface of Armco ALUMINIZED Steel. Up to 900 F., about 80% of the radiant heat sent against this special aluminum-coated steel is reflected.

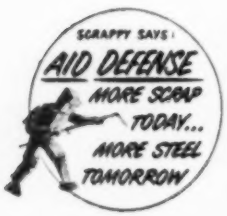
Armco ALUMINIZED gives your products good resistance to a *combination* of heat and corrosion too. Generally, aluminum melts at about 1200 F. But you'll find the hot-dip aluminum coating on ALUMINIZED Steel doesn't melt off at its melting point!

Seems strange, doesn't it? But there's a good reason.

An iron-aluminum alloy starts to form above 900 F. It serves as a good refractory layer up to 1250 F. When it is changed to an alloy the aluminum puts up a protective "fire wall"; the steel core supplies the strength.

If your products are exposed to temperatures in the 300-1250 F. range, let us give you complete information on Armco ALUMINIZED Steel. It is supplied in a wide variety of gages and sizes in sheets and coils.

Write us at the address listed below.

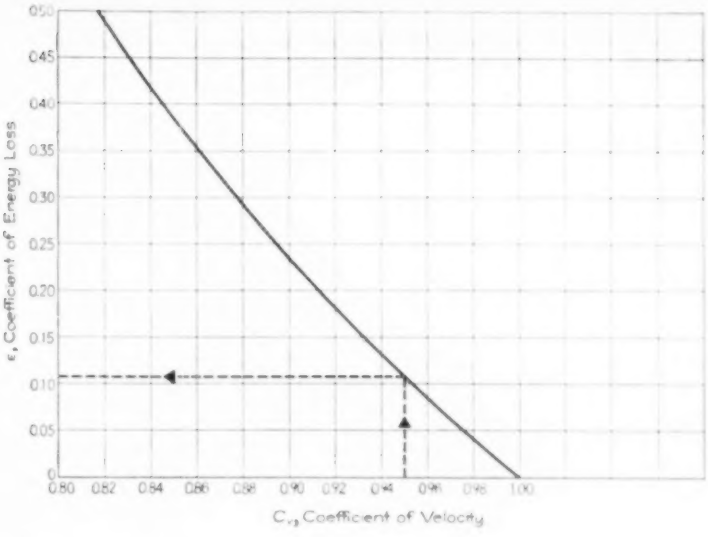



**ARMCO STEEL CORPORATION**

2802 CURTIS STREET, MIDDLETOWN, OHIO • PLANTS AND SALES OFFICES FROM COAST TO COAST • EXPORT: THE ARMCO INTERNATIONAL CORPORATION

ARMCO

# Fluid Flow Losses Through Orifices




NILS M. SVERDRUP
Aerojet Engineering Corp.

The losses in orifices can be calculated by the equations:

$$P = 1.123 \times 10^{-3}\, G^2\, S\, \epsilon\, D^{-4}\, C_c^{-2} \qquad (1)$$

or $$H = 2.591 \times 10^{-3}\, G^2\, \epsilon\, D^{-4}\, C_c^{-2} \qquad (2)$$

where:

$P$ = pressure drop, psi
$G$ = rate of flow, U. S. gpm
$S$ = specific gravity
$\epsilon$ = coefficient of energy loss
$D$ = diameter of orifice, in.
$H$ = head loss, ft
$C_c$ = coefficient of contraction

In these equations, the variable $\epsilon$ needs amplifying. This coefficient is defined by the relationship:

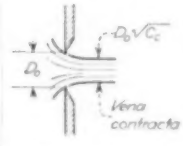
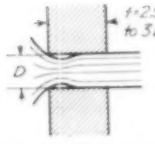
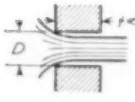
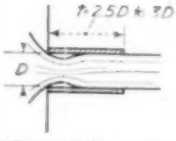
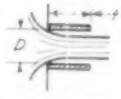
$$\epsilon = \frac{1}{C_v^2} - 1 \qquad (3)$$

where $C_v$ is the coefficient of velocity. Eq (3) is represented graphically above. The table lists values of coefficients for several types of orifices.

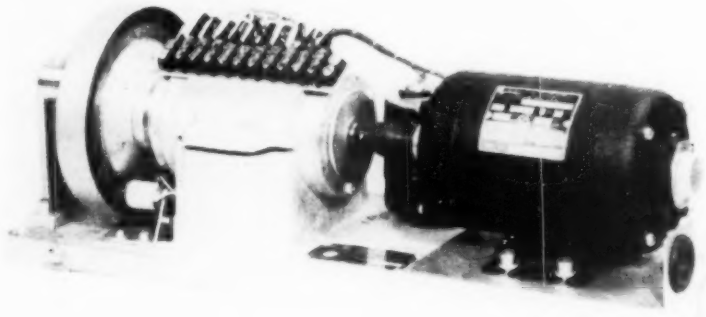
Instead of solving Eqs (1) or (2) for $P$ or $H$, these losses can be determined by the chart (Fig. 8) in PRODUCT ENGINEERING April 1951, p 152.

EXAMPLES Fluid AN-0-36 (S is 0.838) at 80F flows through a sharp-edge orifice $D$ = 0.25 in. at 9 U. S. gpm.

From the table, $C_v$ is chosen to be 0.95 and the graph shows that $\epsilon$ is 0.108. Then solving Eq (1): $P$ = 5.15 psi.

| Type of Orifice | | Coefficients of: Contraction $C_c$ | | Velocity $C_v$ | Discharge $C_D$ | | |
|---|---|---|---|---|---|---|---|
| | | $D_o/D$ | | | $D_o/D$ | Laminar $R$ = 2000 | Turbulent $R$ = 10,000 to 70,000 |
| Thin-Wall Sharp-Edged |   | 0.25 to 0.40 | 0.64 | 0.950 to 0.994 | 0.3 | 0.64 | 0.62 |
| | | 0.7 | 0.68 | | 0.5 | 0.67 | 0.64 |
| | | 0.8 | 0.73 | | 0.7 | 0.71 | 0.66 |
| | | 0.9 | 0.82 | | | | |
| Bell-Mouth | | 1.0 | | 0.98 to 0.99 | | | |
| Thick-Wall |   | 1.0 | | 0.80 to 0.82 | | | |
| |   | 0.62 to 0.64 | | 0.92 to 0.98 | | | |
| Short Tube |   | 1.0 | | 0.80 to 0.82 | | | |
| |   | 0.62 to 0.64 | | 0.92 to 0.98 | | | |
| Nozzle | | 1.0 | | 0.975 to 0.99 | | | |

# Shaft Position Indicator With Digital Output



This shaft monitor, shaft-position indicator system rapidly and accurately detects the angular position of a rotating shaft, and converts the resulting indications to a digital representation. It uses a magnetic recording mechanism to detect, on command, and as often as twenty times a second, the position of a reference shaft. Other circuits convert the analog position indication to digital form.

Accuracies of better than one tenth of a degree are possible. The measurements may be sent to another location and displayed as visual indications in digital form, put on magnetic tape, punched tape, or punched cards for future analysis.

The shaft monitor consists of two major components: an electromechanical locator unit which couples to the reference shaft, and an electronic converter unit.

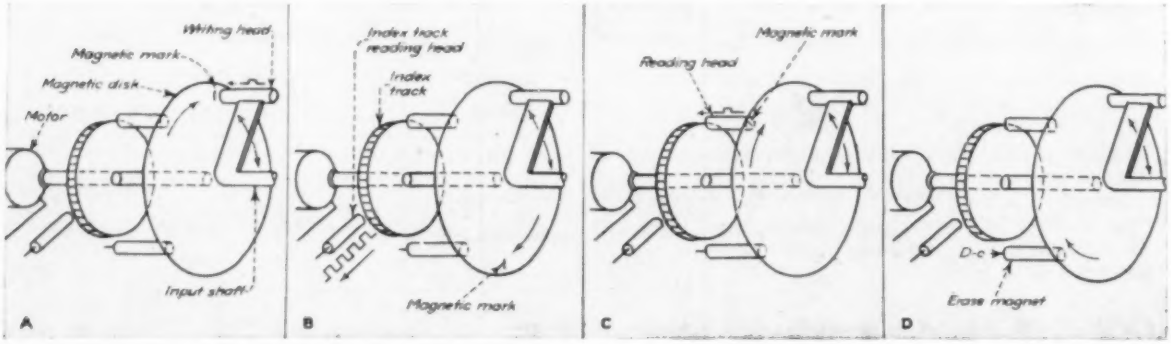
The locator contains a rotor plate, on which is mounted a magnetic writing head, and a magnetically coated disk which is driven at a relatively constant speed by an electric motor. A magnetic reading head and an erase solenoid are mounted near the periphery of the disk. A permanent index track with 500 index marks is attached to the disk and rotates with it. A separate magnetic reading head is mounted adjacent to the index track.

The converter is constructed on a single electronic chassis and contains amplifying, frequency multiplying, shaping, delay, and all necessary control circuits. The unit is of turret type construction, in which all the parts associated with each stage of the converter are contained in a plug-in can. This eliminates circuit tracing problems.

In operation, the input shaft of the locator is mechanically coupled to the reference shaft. Therefore, the position of the writing head at any time corresponds to the position of the reference shaft. At the instant that the reference shaft position is determined, the writing head puts a magnetic mark on the magnetic disk. Readout of a train of pulses generated by the index track reading head is initiated by the "write" pulse. The index pulses appear at the output of the shaft monitor until the reference mark passes the reading head. The number of pulses in the pulse train represents the shaft position at the time the read signal was initiated. In system application, this pulse train is fed to a coding unit where the pulses are coded in decimal digit form.

The locator drive motor is a precision synchronous type rated at 1/20 hp, 115 v, single phase, 60 cycle, 0.9 ampere. The converter power input is +300 v, 210 ma; —105 v, 35 ma; ± 60 v d-c, 24 ma (erase supply); 115 v, single phase, 60 cycle, 600 ma (filament supply).

*Engineering Research Associates, Inc., 1902 W. Minnehaha Ave., St. Paul, Minn.*




**A. Magnetic mark is "written" on revolving magnetic disk at instant of read signal initiation. B. Index track reading head generates train of index pulses. Converter triples frequency and shapes pulses which appear as output of Shaft-Monitor. C. Reading head detects magnetic mark and stops index pulse train, the length of which represents time between time magnetic mark was written and read. D. Erase magnet is energized for one revolution of magnetic disk, preparing disk for next reading.**

# Heavy Duty Elevator Pump Has Quiet Operation

This heavy duty, high capacity, hydraulic elevator pump has three rated capacities at 300 psi. At 1,800 rpm the output is 110 gpm; at 1,200 rpm it is 73 gpm; and at 900 rpm the output is 55 gpm. Maximum quietness is obtained at the reduced speed.

The pump has three pairs of equal sized helical pumping gears. Their relatively small diameter gives a low tooth velocity. The length of the gear provides a long wrap around of the tooth form, and the low helix angle gives minimum end thrust. This design achieves efficiency and quietness of operation with uniform flow. The accurate finish on the gears is produced by crossed axis laping which makes the pumping elements easy running and mechanically quiet.

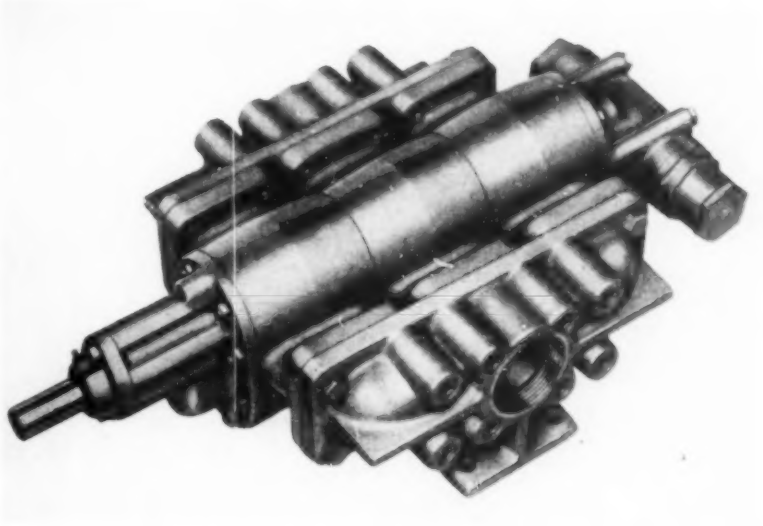
The high lead bronze sleeve bearings that support the drive shaft have circulating oil grooves for positive lubrication. The stationary idler shaft is made of bronze and has lubrication channels. One of the features of the two larger sizes is the bearing spacers of cast iron with bronze inserts which align the sections of the pump case, and give an additional bearing for the shaft. On all models the bearing loads are evenly distributed.

The built-in relief valve is adjustable over a wide range, and has high performance characteristics. By eliminating the piping necessary for external relief valves, the built-in valve saves space, assembly time, and reduces the possibility of hydraulic noise. They operate without chatter, and protect the system from overload.

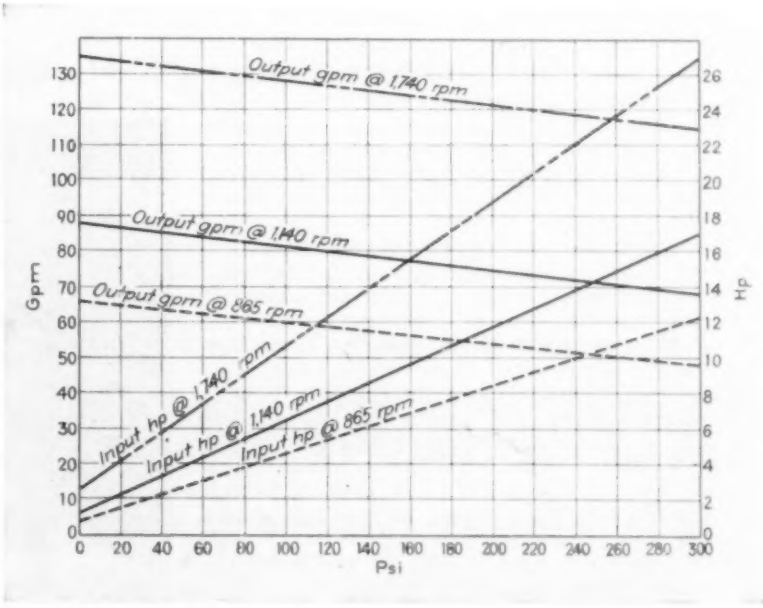
A special venturi suction and discharge principle is designed in these pumps to reduce turbulence and improve efficiency. The action of the venturi causes the flow form of the oil to spread out across the full width of the pumping gear and completely fill the tooth spaces. The shape of the openings coordinates the oil velocity to the gear speed.

Shown in the illustration is the model 2K110 pump with built-in relief valve. The graph gives the operating speeds of the model 2K110 pump on 300 S.U.S. oil at 100 F.

*George D. Roper Corp., Rockford, Ill.*



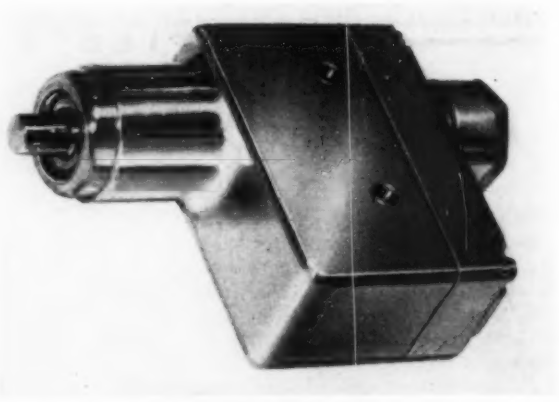
**SHOWN IS THE MODEL 2k110** with a capacity of 110 gpm at 1,800 rpm. The drive shaft is of hardened steel, and the idler shaft of bronze, flat on the bottom for lubrication channel. The built-in relief valve is easily adjustable over a wide range.

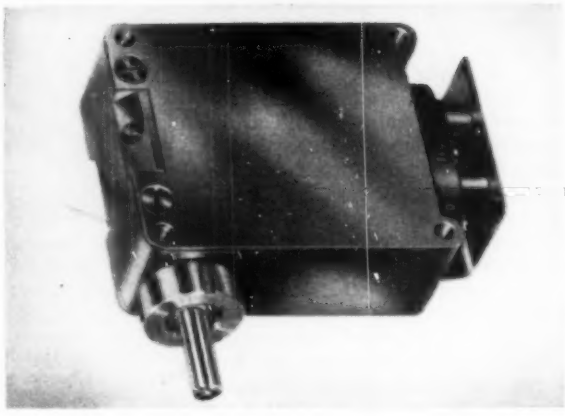



**THE GRAPH SHOWN** is for the model 2k110 elevator pump with three pairs of equal sized helical pumping gears. Other models available are the 2K80, or the medium size with 2 pairs of pumping gears and an 80 gpm capacity, and the 2K50 with two pumping gears and a 50 gpm capacity. The built-in relief valves reduce hydraulic noise.

CONTINUED ON PAGE 240

## Immersion-Proof Switch With High Pressure Plunger





Equipped with a high-pressure actuating plunger built to break away heavy ice formations in either direction of plunger movement, the model X-101, immersion-proof, aircraft, precision switch, shown at bottom, is said to give reliable performance under all environmental conditions.

The switch assembly is made up of a standard AN-3210-1 or AN-3216-1 precision switch mounted in an aluminum housing sealed against entrance of moisture. The electrical connections are brought out to a terminal block having five terminals with binder head screws.

Other characteristics of the X-101 are: operating force, 22 lb; force for full overtravel, 35 lb; release force, 16 lb; pre-travel, $\frac{3}{16}$ in.; overtravel, $\frac{1}{2}$ in.; differential travel, $\frac{1}{8}$ in.; weight, 8 ounces.

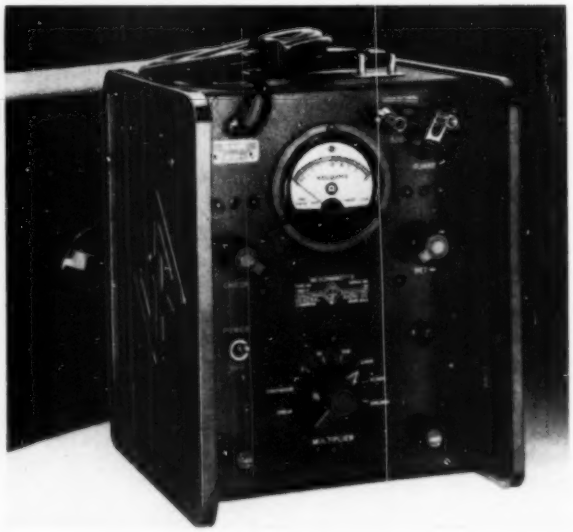
Also classified as an all-weather switch is the model LK precision switch, shown at top, which is being used in aircraft landing gear and flap controls. This switch is also impression-proof.

The switch is designed for single-pole, double-throw service at a current rating of 10 amp resistive load at 28 v d-c. O-ring seals that will withstand pressure differentials up to 15 psi prevent entrance of moisture.

The sealed overtravel plunger is built to break away ice accumulations in either direction of travel. Actuating force is 10 lb.; at full overtravel, force is 15 pounds. Movement characteristics are: pretravel, 0.093 in. max, overtravel, 0.187 in. minimum; differential, 0.032 inch.

*The W. L. Maxson Corp., Unimax Switch Div., 460 W. 34 St., New York 1, N. Y.*

## 500 Volt Megohmmeter for Insulation Testing



The simple operation of this type 1862-A megohmmeter makes it possible to get fast measurement of insulation resistance as well as general resistance testing. By turning a multiplier switch, the resistance is read directly from a meter and the multiplier setting.

The range of this meter, from 0.5 megohm to 2,000,000 megohms, is great enough to make it useful for testing insulation of rotating machinery, transformers, cables and household appliances. Six decade ranges are used and each decade covers about 90 percent of the meter scale. The relatively low resistance of the megohmmeter circuit makes the rapid measurement of capacitor leakage resistance a major application.

A constant test voltage of 500 v is applied to the resistance under test as per ASTM Standards on Electrical Insulating Materials, D257-49T. The discharge position of the multiplier switch removes all voltage from the terminals. Separate guard and ground binding posts are used for making three-terminal resistance measurements.

The type 1862-A megohmmeter has been designed for field as well as laboratory applications. The entire instrument is of heavy construction and uses a completely enclosed carrying case. The size and weight have been kept small, and operation is direct from the a-c power line.

*General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.*

CONTINUED ON PAGE 242

# for precision performance!

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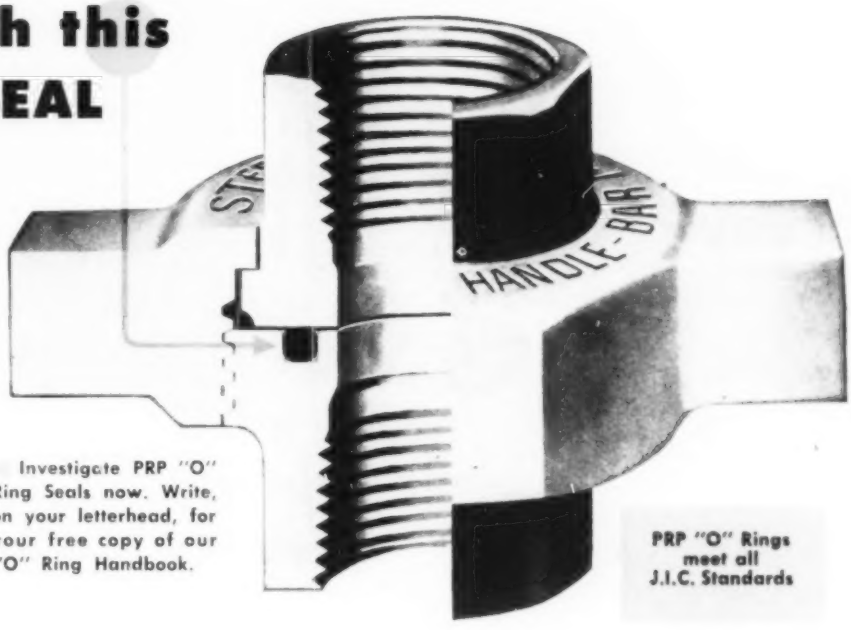
Investigate PRP "O" Ring Seals now. Write, on your letterhead, for your free copy of our "O" Ring Handbook.

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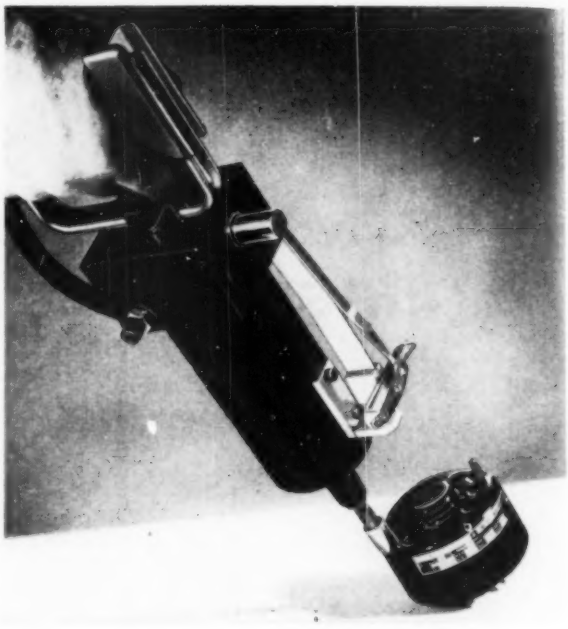
**Dept. 3, Oakridge Drive, Dayton 7, Ohio**

## Precision Air Powered Torque Tool



A new air-powered nut runner, power torque tool, model MA-25, gives exact torque control in the 0-25 in.-lb range, with special gearing making it possible to extend this torque range to 40 in.-pounds. The exact torque is easily set by using the built-in torque wrench as a gage.

This tool is used on production jobs where too much torque would cause breakage or distortion of light metal parts, castings, or plastic. The torque tool is said to be accurate to 2 percent of torque limits, and would eliminate the need for hand torquing inspections.

The torque-tool is used as a nut runner; when the predetermined torque is reached, it stops automatically.

The illustration shows the power-torque-tool in operation, driving a nut on the housing stud of fractional horsepower fan motor. The tool is adaptable to horizontal, vertical or angular operation; quick-change type of wrench adapters are available.

The complete unit includes a remote control box containing solenoid valves and control switches.

*Gattin Bros., Inc., Box 536, South Bend 24, Ind.*

## Armor Cable Protects Hydraulic Control Lines

A flexible, protected, multi-tube transmission line is now being used to prevent damage to hydraulic control circuits.

Known as armor-tube cable, it is made up of bundles of ¼ in. O.D. aluminum or copper tubing gathered in a slow continuous spiral, similar to the construction of rope. The tube bundle is first wrapped in water-repellent insulating tape; then encased in heavy, rust-resistant, galvanized steel strip like that used for BX electrical cable.

Its features are: protecting instrument and control lines; conserves space; cut installation time and costs.

Available in bundles of 4, 8 and 12 tubes, this cable is capable of handling hydraulic control pressures as high as 3,000 psi and all ranges of pneumatic control pressures. Standard electrical junction boxes may be used.

The armor tube is shipped in random lengths of approximately 500 ft on store returnable reels. The O.D. of the cable containing 12 tubes is 1.32 inches. The weight is 0.85 lb/ft for aluminum, and 1.45 lb/ft for copper. Minimum bending radius is 9 inches.

*Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio*

## Silent Air Valve For Heating Systems

A new steam air valve works on a new principle, and measures only ¾ in. x 1 in., or less than a quarter of the size of conventional air valves.

Operation is as follows: (1) Air is forced out between special composition disks by steam pressure; (2) As steam enters the valve, the moisture in the steam starts to swell the disks; (3) The disks are sized and of such material that they will not completely seal until all air has been forced out and the valve is full of steam; (4) After the steam subsides, and the system goes into a vacuum, the disks dry and shrink and are ready for another cycle.

*Taco Heaters, Inc., 137 South St., Providence 3, R. I.*

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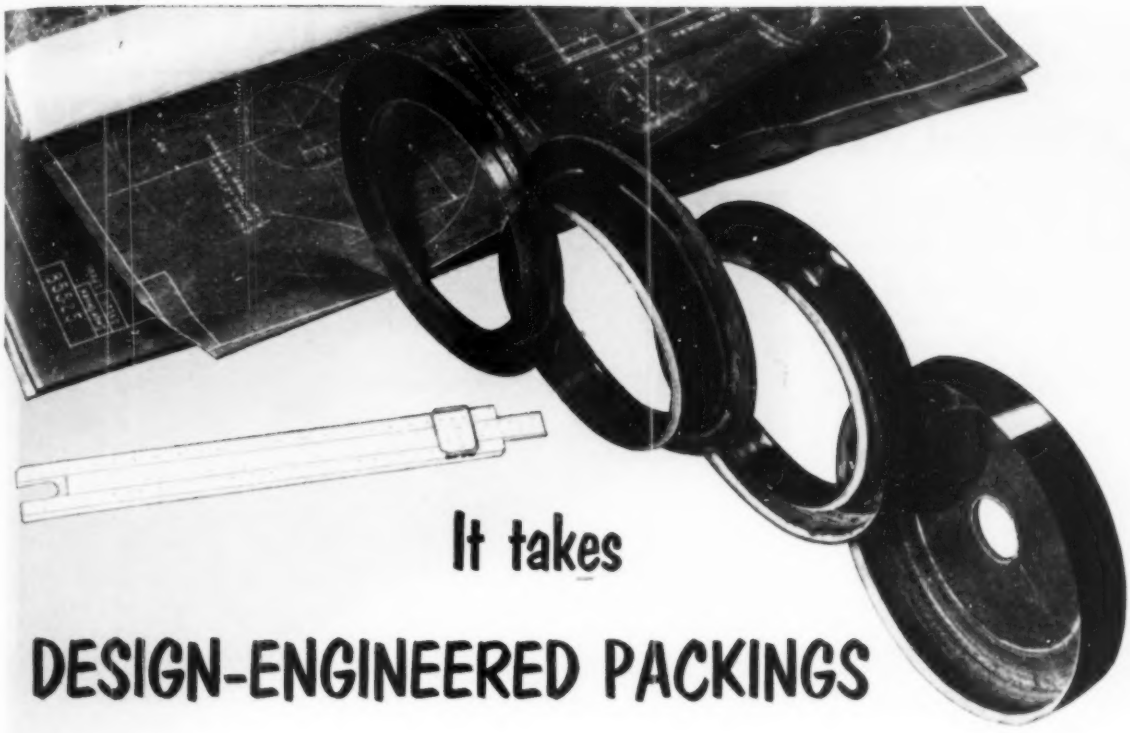

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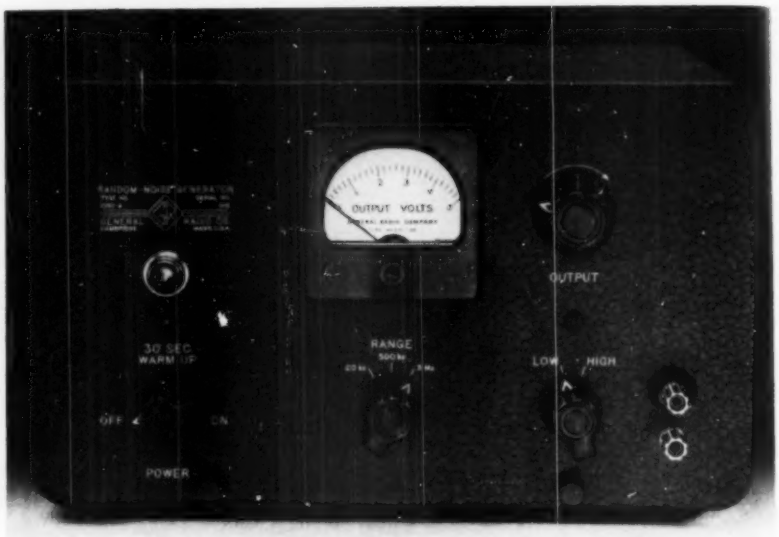
# Electrical Noise Generator Aids in Measurement

Properly controlled electrical noise has been found to be a useful signal, and has made possible a new approach to measurement problems. Typical applications of the new type 1390-A Random Noise Generator include room acoustics measurements, loudspeaker and microphone tests, psycho-acoustic tests, filter tests, calibration checks on recording systems, observations of resonances and electrical averaging of resonant responses, comparisons of effective band width, and crosstalk measurement on multi-channel systems.

A gas-discharge tube operated in a magnetic field is the noise source. Two stages of amplification and suitable filters make it possible to have an open-circuit output voltage of one volt on the three frequency ranges, extending from 30 cycles to 20 kilocycles, 500 kilocycles, or 5 megacycles. The normal or gaussian distribution of amplitudes is good with only moderate clipping on the 500 kc and 5 mc ranges.

A panel output control and voltmeter is used on the generator and where relatively low levels are required it will be possible to use an external type 700-P1 voltage divider.




The broad frequency spectrum of the noise generator is useful for measuring the response of circuits and systems in place of the usual sine-wave generator. For many of these applications, the noise source more nearly approaches normal operating conditions than does the older system. This approach is said to be useful in testing recording systems.

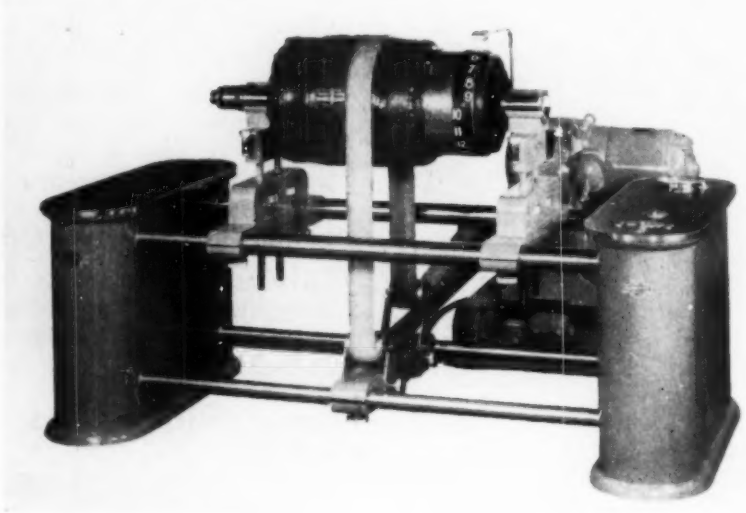
*General Radio Co.*
*275 Massachusetts Ave., Cambridge, Mass.*

# Measures Static, Dynamic, and Total Unbalance

With a single control, this balancing machine can be set to indicate the static, dynamic, or complete unbalance of any rotating part. An electronic stroboscope picks out the position, and the meter indicates the value of unbalance in each of the two correction planes, all in the space of two seconds.

Using only an endless belt drive, it is possible to get smooth operation of the work piece at any desired speed. The V-type bearings take all shaft sizes with perfect fit. The bearings are also adjustable to take care of work pieces with different diameter journals on opposite ends. The work supports are mounted on ball bearings, and give freedom of movement in any direction such as the end thrust of fans and propellers. Any lateral or rotational movement is indicated.

The control dial is available in electronic magnetic, Piezo electric, and mechanical types. Two simple settings of this single dial determine the static, dynamic, and total unbalance. The control dial may be operated in front, or swung around to the rear.



*The Welch Mfg. Co., 920 W. Laurel St., Springfield, Ill.*

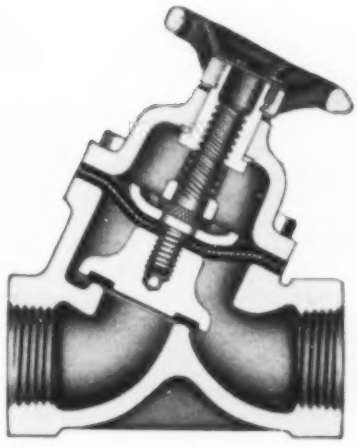
CONTINUED ON PAGE 246

# For the full piping story...
# Turn to your CRANE Catalog

You're never up against a piping problem long when you reach for your Crane Catalog. In this one valuable book you'll not only find an unequaled selection of quality piping materials—but *all* the specification data you need. For each item, Crane lists sizes and dimensions, pressure and temperature ratings, and gives complete design, material, and construction details.

In addition, there's an abundance of general engineering information to help you design better piping systems. And it's all there conveniently arranged and indexed to save you time.

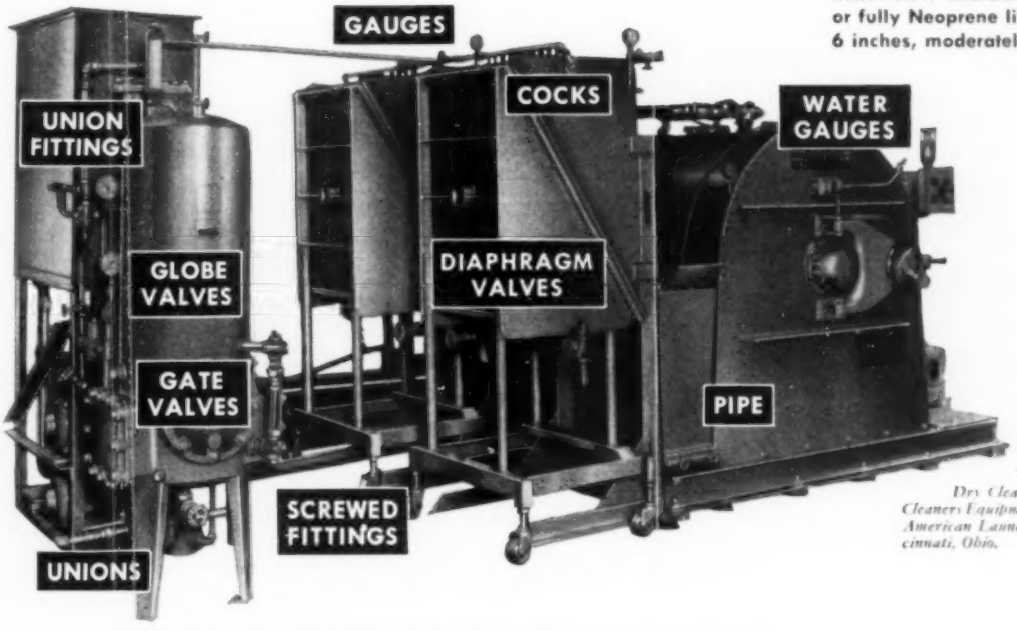
But even more important, when you specify Crane, you know the finished product will be equipped for most efficient flow control. And in times like these when equipment must work harder and last longer, the proved dependability of Crane takes on an importance no machinery buyer can afford to overlook.



**FOR BETTER RESULTS**

**For volatile and hard-to-hold fluids, Crane recommends Iron Body, Y-Pattern Diaphragm Valves. In fact, you can specify this improved "packless" valve for a wide range of services. Note, in Crane design, the diaphragm serves but one purpose—sealing the bonnet. Longer diaphragm service life is assured. The separate disc gives positive shut-off in case of diaphragm failure. Y-Pattern design gives better flow characteristics. Unlined or fully Neoprene lined. Sizes ½ to 6 inches, moderately priced.**

***YOU'LL FIND THE ANSWER TO BETTER PIPING IN THE BROAD CRANE LINE***




*Two-Bath TRUCLEEN Dry Cleaning Unit by American Cleaners Equipment Co. A Division of the American Laundry Machinery Co., Cincinnati, Ohio.*

*The Complete Crane Line Meets All Your Valve Needs. That's Why—*

**More Crane Valves Are Used Than Any Other Make!**

# CRANE VALVES

CRANE CO., *General Offices:* 836 S. Michigan Ave., Chicago 5, Illinois

*Branches and Wholesalers Serving All Industrial Areas*

***VALVES • FITTINGS • PIPE • PLUMBING • HEATING***

# Scale Gives Automatic Cumulative Weighing

Through application of a servo-mechanism used in processing controls, a scale has been designed to give automatic cumulative and consecutive weighing. Possible uses of the device, known as the Select-O-Weigh, are said to be unlimited in the chemical and processing industries, as the scale makes possible automatic weighing in small plants by having one automatic scale do the same work that used to require up to twelve separate scales.

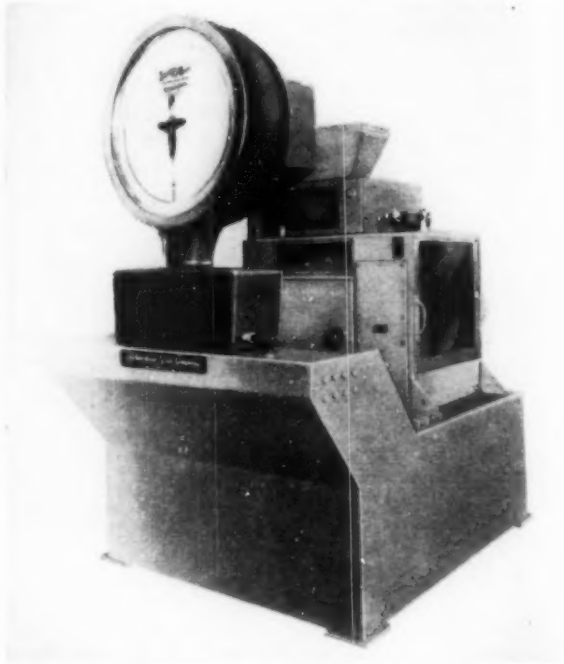
The heart of the scale is an electronic circuit with no arcing contacts, making it applicable for explosion-proof installation. A standard type automatic scale is used as the weighing element in the system, with a pendulum dial scale acting as the force measuring component. A large number of possible dial scale settings make possible a variety of operation as well as a wide range of capacities for proportioning applications.

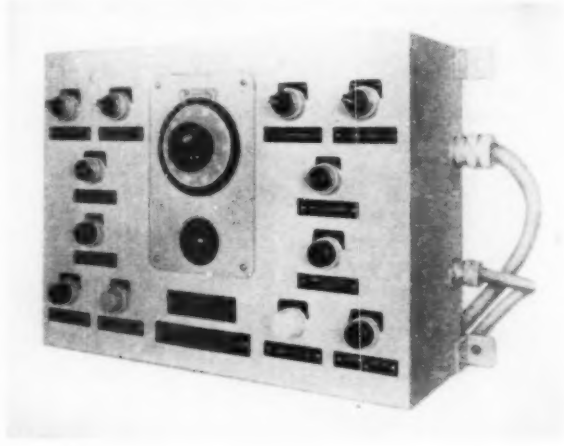
A master control panel for any particular system is built to include as many setting dials as there will be ingredients in formulae handled, with one dial for each ingredient. It is possible to operate the system for from two to twelve ingredients. The scale operator, who may be located in any part of the plant remote from the actual weighing operation, sets each dial on the control panel to correspond with the amounts of each ingredient in his formula. Sequence of adding materials and their timing are controllable.

After setting up the control panel, the start button is pressed. This actuates the screw feeder mechanism, delivering to the automatic scale the amount of material set on the first control dial, and then stopping. This action is visible on the scale dial. Then, depending upon the settings of the various selections and controls, the scale either discharges to a mixer or goes on to the next ingredient, repeating the cycle and adding this ingredient to the weigh hopper in the amount indicated by setting on the second control dial. Again, the pointer on the dial moves to its new position, as the material is added, and stops the action. Control circuits may be so arranged as to provide either delivery of consecutive weights of varying amounts, or accumulation of a total batch of a pre-selected formula and its discharge to a surge hopper or mixer as a whole.

Following discharge of the automatic scale, a tare check circuit is brought into operation to prevent the scale from initiating the next weighing unless all material is cleared from the weigh hopper and the unit is in empty balance.

*Richardson Scale Co., Clifton, N. J.*





# Light Weight High Tensile Strength Locknut

Originally designed for aircraft use, an external wrenching nut has been made that can be applied wherever space is limited and high tensile strength is required.

Known as the Flexloc nut, it combines high strength with minimum size and weight with the tensile strengths being in excess of 160,000 pounds per sq. inch. For example, the 1¼ in. size has a minimum tensile of 193,700 lb, but weighs only 0.52 of a pound. Designed with a large bearing surface, it has 12 point serrations to fit standard box or socket wrenches for use in restricted space.

Because it does not have to seat to lock, the flexloc is considered a stop-nut as well as a locknut, locking in any position on a threaded member. All-metal, one-piece construction permits its use at temperatures up to 550 F.

The flexloc external wrenching nut is approved in sizes from ¼ inch to 1½ in. in the NF thread series.

*Standard Pressed Steel Co., P. O. Box 545, Jenkintown, Pa.*

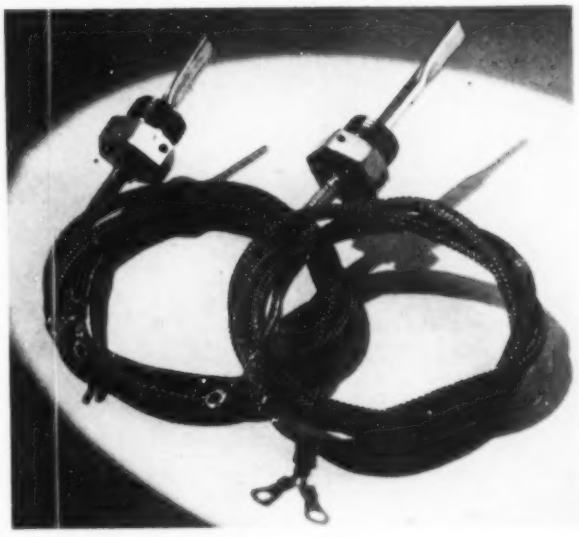
CONTINUED ON PAGE 248

# Temperature Pickup Has Short Thermal Constant

A series of temperature pickups, type 21, measures temperatures up to 1,832 F, and has a high voltage output (0-1 volt) as its outstanding feature. In addition, it has a short thermal time-constant of less than one second in water.

These pickups have a resistance change of 50 ohms over their specified temperature ranges and may be excited with 20 milliamperes, rms. Several ranges between 32 to 212 F and 32 to 1,832 F are standard. The sensing element of the type 21 temperature pickup is contained within a spade-shaped tip of a stainless steel case. With the thermal time constant of this cased instrument being less than 1 second in water, it may be used to follow very rapid thermal transients. Each instrument has a calibration certificate, with the units guaranteed to have an accuracy of ±1 percent of full scale. The resistance change is linear with respect to temperature except for the highest ranges which have a curvature of a few percent.

The standard instruments are supplied in 18-8 stainless steel or inconel cases, and are suitable for insertion in high pressure liquid and gaseous systems. Other steels or alloys, such as 316 stainless steel, have been supplied to special orders for use with corrosive fluids.



The type 21 temperature pickups are said to be well suited for telemetering, recording, and remote indication of liquid and gas temperatures. The pickup's output impedance is sufficiently low, (approximately 50 ohms) so that a step-up transformer may be used to raise the voltage by a factor of ten or twenty times. Power thytron control of electric furnaces and telemetering channel inputs, become possible without intermediate amplification. In addition, these resistance thermometers may also be used to actuate milliameters and sensitive relays, directly.

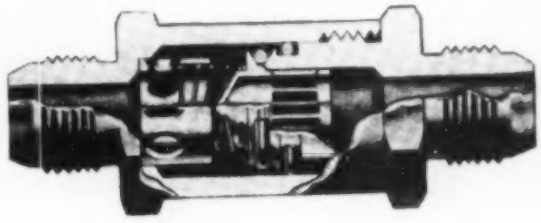
*Trans-Sonics, Inc., Bedford Airport, Bedford, Mass.*

# Tight Sealing, High Pressure Check Valve

A new valve, designed specifically for high pressure air or nitrogen requirements from 0 to 3,000 psi, has been added to a line of circle seal check valves. Known as the model 299A-4TT, it uses the circle seal principle which gives dead tight sealing not only at high pressures, but at very low pressure differentials. Unlike check valves that do not maintain their seal at low pressure differentials, the 299A-4TT is said to protect the pneumatic system even when small leaks in the system set up a slight pressure differential across the valve.

The O-rings furnished are AN 6290 compound molded to AN 6227 size. This O-ring, of 90 durometer compound, is said to have advantages over the softer AN 6227 compound when used for high pressure gas service. The manufacturer says that AN 6227 O-rings can be used for emergency replacement, but that in their field experience, they have never found it necessary to replace an O-ring because of wear on any of their circle seal valves.

The 299A-4TT check valve is manufactured of aluminum.



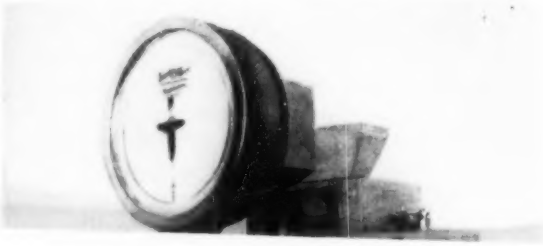
Weight, approximately 1 ounce. Hex size, $\frac{3}{4}$ inch. Length conforms to AN 6249-4. Operating pressure is 0-3,000 psi; proof pressure 6,000 psi; and burst pressure over 7,500 psi. Operating temperature is from -65 to 165 F.

*James-Pond-Clark, 1247 East Green St., Pasadena 1, Calif.*

A NEW PANEL MATERIAL named Plyron combines the strength of plywood with a smooth, tough surface of hardboard, and has been used successfully for concrete forms, flooring, cabinet doors, and table tops. Produced in 4 x 8 ft sheets, the material is usually made in $\frac{1}{8}$ and $\frac{1}{4}$ in. thicknesses. Larger sizes and thicknesses up to 2 in. are available. Hardboard, which is made by compressing wood fibers into a thin hard sheet, forms a moisture resistant outer surface. It is splitproof and warp resistant. Douglas Fir Plywood Assoc., Tacoma, Wash.

CONTINUED ON PAGE 250

# Scale Gives Automatic Cumulative Weighing



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*Richardson*

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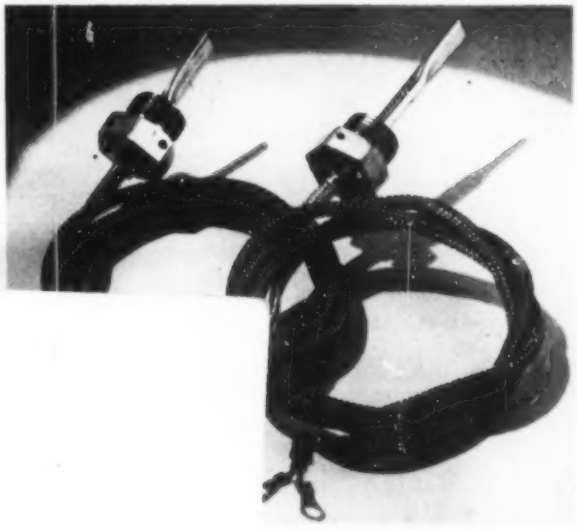

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*nc., Bedford Airport, Bedford, Mass.*

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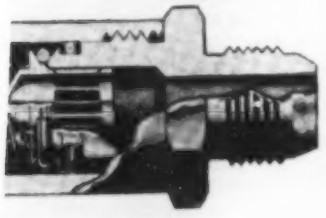
## Valve



l ounce. Hex size, ¾ inch. Length
Operating pressure is 0-3,000 psi;
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is from -65 to 165 F.

1247 *East Green St., Pasadena 1, Calif.*

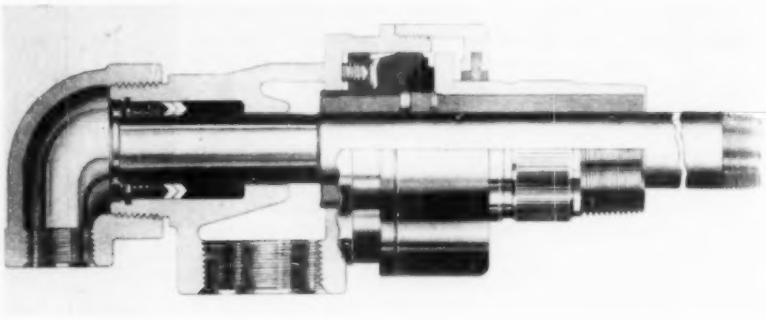
ıde by compressing wood fibers into
thin hard sheet, forms a moisture
sistant outer surface. It is splitproof
d warp resistant. Douglas Fir Ply-
ood Assoc., Tacoma, Wash.

——CONTINUED ON PAGE 250

# Stationary or Rotating Syphon on Revolving Joint

This new revolving joint, which compensates for all roll misalignment, requires no lubrication and can be mounted with solid piping for use on steam. In addition, by changing the rotor and nut, it can be used with flexible hose.

These joints are capable of handling pressures up to 300 lb in steam, air, oil, gas and other fluids, temperatures from minus 100 to plus 500 F, and are resistant to all known acids. They are short in overall dimensions, made with stationary or rotating syphon, and come in sizes from ½ to 5 in. inclusive.



Rotation takes place on the flat face of a non porous carbon disk. The opposite side of this disk is a ball seat which permits the rotating sleeve to find its own rotating center regardless of the eccentricity of the roll or threads. The shape of this carbon eliminates all breakage because in the event of shock it would have a tendency to compress rather than separate.

The seal inside the casing is a spring seated teflon wedge against a chrome plated surface on the face of the rotating sleeve. This acts as an expansion joint as well as taking care of all roll and play. The entire sealing assembly is one complete unit that can be removed without taking either rotating member from the roll.

The revolving joints require no lubrication. They have no bearings, and require no flexible hose for mounting.

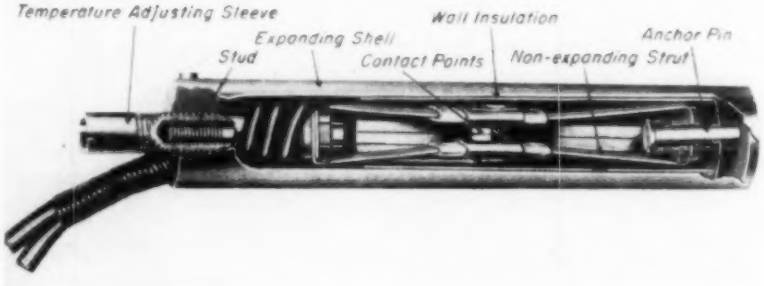
The YX model has the stationary syphon, and the YR model has the rotating syphon, in which case both the rotating members will rotate on their own centers without strain.

*Rotbern Engineering Co., Inc., 4911 W. Irving Park Rd., Chicago 41, Ill.*

# Sensitive Thermostatic Control Switch Units

Completely enclosed to protect the working parts, the thermoswitch control responds to small amounts of temperature changes with a sensitivity of less than 0.1 F.

A regular thermoswitch, when used in a process to control the temperature within certain limits, will close the heater circuit when the temperature at the switch unit drops below the desired value, and opens when the temperature rises above the correct value. This control can only turn the heat on and off in accordance with its operating differential, which is a function of the voltage, current, temperature setting, and location of the thermoswitch in the system.




The switch is constructed with two silver contacts mounted on, but electrically insulated from, curved nickel-iron struts of low expansion coefficient. This assembly is mounted under tension or compression in a seamless brass or stainless steel tube. This tension or compression is variable, depending on the position of the adjusting sleeve and the temperature of the shell. Changes in temperature cause the shell to expand or contract, causing the contacts to make or break.

Switches may be had in regular construction (the contacts open on a temperature rise), or inverse construction (contacts close on temperature rise). These types may be tension or compression operated. Shown in the illustration is the regular, tension operated switch.

Current ratings are 10 amps at 115 v a-c, or 5 amps at 230 v a-c (standard series), and 25 amps at 115 v a-c, or 12.5 amps at 220 v a-c (heavy duty series). The thermoswitch is not recommended for use above 250 v a-c.

These switches have been used effectively in selenium rectifier power units, allowing them to operate at maximum efficiency without danger of overheating. The thermoswitch is also being used to control the heating elements in a vapor degreaser.

The Thermoswitch units can be adjusted to operate a few degrees apart with high precision and simplifies the method for getting the small time lag between the operation of the alarm and the shut-off system.

*Fenwal, Inc., Ashland, Mass.*

CONTINUED ON PAGE 252

Whenever the Service is TOUGH—

Engineers specify MEEHANITE CASTINGS!

Fig. 2

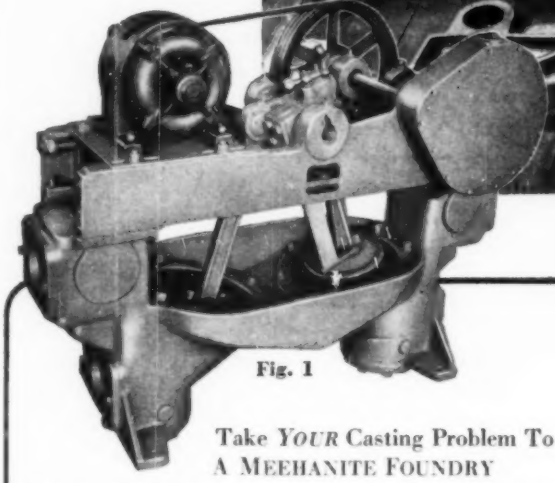


Fig. 1

THE DORRCO V-type Diaphragm Pump (Fig. 1) manufactured by the Dorr Company, Stamford, Conn., was designed for handling sludges, pulps or slimes which contain sizable quantities of solid material. In keeping with their international reputation as builders of dependable and efficient equipment, designed to provide better service life under severe operating conditions, the Dorr Company regularly designs to and specifies Meehanite engineering characteristics.

Note that the Meehanite castings (Fig. 2) used in this specific unit reveal the fact that every major component is a Meehanite casting. These castings provide the necessary strength, toughness and resistance to wear and corrosion demanded by the service functions of such a pump.

Write for our new 20-page Pump Bulletin No. 36 which gives complete details not only on pump applications but various specific property tests as applied to impact, erosion, corrosion and wear.

MEEHANITE®

NEW ROCHELLE, N. Y.

Take *YOUR* Casting Problem To A MEEHANITE FOUNDRY

American Brake Shoe Co. . . . . Mahwah, New Jersey
The American Laundry Machinery Co. . . . . Rochester, New York
Atlas Foundry Co. . . . . Detroit, Michigan
Banner Iron Works . . . . . St. Louis, Missouri
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E. W. Bliss Co. . . . . Hastings, Mich. and Canton, O.
Builders Iron Foundry . . . . . Providence, Rhode Island
Compton Foundry . . . . . Compton, Calif.
Continental Gin Co. . . . . Birmingham, Alabama
Crawford & Doherty Foundry Co. . . . . Portland, Oregon
The Cooper-Bessemer Corp. . . . Mt. Vernon, Ohio and Grove City, Pa.
Empire Pattern & Foundry Co. . . . . Tulsa, Oklahoma
Farrel-Birmingham Co., Inc. . . . . Ansonia, Connecticut
Florence Pipe Foundry & Machine Co. . . . . Florence, New Jersey
Fulton Foundry & Machine Co., Inc. . . . . Cleveland, Ohio
General Foundry & Manufacturing Co. . . . . Flint, Michigan
Greenlee Foundry Co. . . . . Chicago, Illinois
The Hamilton Foundry & Machine Co. . . . . Hamilton, Ohio
Hardinge Company, Inc. . . . . New York, New York
Hardinge Manufacturing Co. . . . . York, Pennsylvania
Johnstone Foundries, Inc. . . . . Grove City, Pennsylvania
Kanawha Manufacturing Co. . . . . Charleston, West Virginia
Lincoln Foundry Corp. . . . . Los Angeles, California
E. Long Ltd. . . . . Orillia, Ontario
Otis Elevator Co., Ltd. . . . . Hamilton, Ontario
The Henry Perkins Co. . . . . Bridgewater, Massachusetts
Pohlman Foundry Co., Inc. . . . . Buffalo, New York
Rosedale Foundry & Machine Co. . . . . Pittsburgh, Pennsylvania
Ross-Meehan Foundries . . . . . Chattanooga, Tennessee
Shenango-Penn Mold Co. . . . . Dover, Ohio
Sonith Industries, Inc. . . . . Indianapolis, Ind.
Standard Foundry Co. . . . . Worcester, Massachusetts
The Stearns-Roger Manufacturing Co. . . . . Denver, Colorado
Traylor Engineering & Mfg. Co. . . . . Allentown, Pennsylvania
Valley Iron Works, Inc. . . . . St. Paul, Minnesota
Warren Foundry & Pipe Corporation . . . Phillipsburg, New Jersey

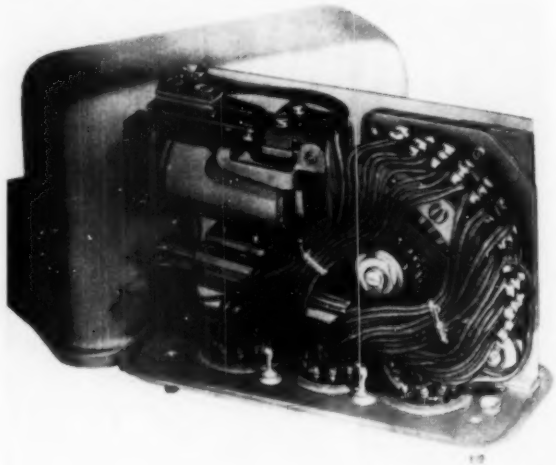
*"This advertisement sponsored by foundries listed above."*

## Hermetically Sealed Rotary Stepping Switch

A series of hermetically sealed enclosures, containing a group of relays or a stepping switch, has been designed to provide an atmosphere of dry, inert gas, which will protect the parts from tampering, high altitude, moisture, ice, dust, fungi, corrosion, and salt spray. In addition, these relays and stepping switches, are resistant to shock and vibration.

Complete relay circuits with up to six relays now can be enclosed in one hermetically sealed unit. Individual relays are also available with a variety of enclosures and terminal connections.

The type 44 rotary stepping switch, shown in the illustration, has up to three bank levels, and is sealed in an enclosure 3¼ x 4 11/16 x 2 3/16 in. in size. It has a maximum self-interrupted speed of about 80 steps per sec., and is available with 10 positions in one, two, or three levels, or with 20 or 30 positions in one level. The switch is designed for any d-c operating voltage up to 110 volts. Hi-Pot insulation and low capacitance springs available.



*Automatic Electric Co., 1033 W. Van Buren St., Chicago 7, Ill.*

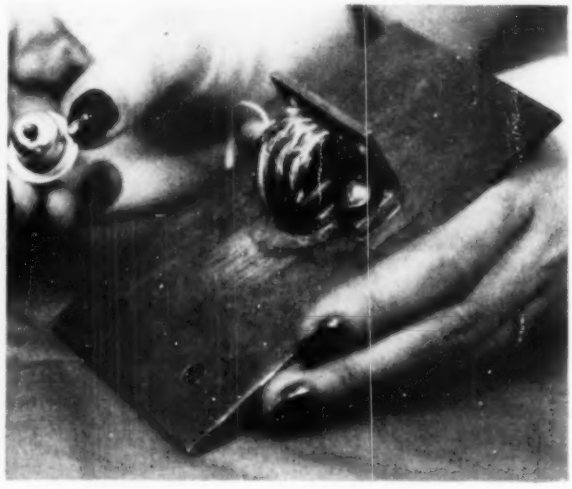
## Small Size, Industrial Germanium Rectifiers

A new line of industrial rectifiers, said to operate at current densities up to 1000 times greater than copper oxide or selenium stacks, are made of germanium, thought to be the best rectifying material discovered. Models now in production include those in single-phase, half wave ratings of 12 v, 0.4 amp; 21 v, 0.4 amp; 27 v, 0.4 amp; and 6 v, 6 amperes.

The industrial germanium rectifiers are designed for power conversion in intricate computing machines, radar devices, and other applications where size and weight requirements are limited. They occupy approximately 10 cu in. per kw of output capacity, compared to the 350 cu in. per kw for selenium.

The manufacturers say that the industrial germanium rectifiers have a high efficiency, since their low forward-drop provides good voltage regulation. The regulation is less than 5 percent when operated at the high current densities permissible with germanium.

Like all metallic rectifiers, these industrial germanium rectifiers are temperature sensitive. They have negative temperature coefficients, with the reverse resistance going down when the temperature increases and the forward resistance going up when the temperature goes down.



*General Electric Co., Lighting and Rectifier Dept., 1 River Rd., Schenectady 5, N. Y.*

## Combination Starter With Fusible Disconnect

A new combination across-the-line motor starter with a fusible disconnect switch is available in sizes O through Z, and is designated as class 11-204-N. The unit consists of a disconnect switch, main line fuse clips, and a line starter mounted in a common enclosure. The switch is of an improved design with visible blades and de-ion arc quenchers. A self-indicating slam-proof handle is provided in the cover. This handle has separate positions for on, off and open cover, and can be locked in the off position.

Enclosures are available for general purpose NEMA type 1, semi-dust-tight NEMA type 1A, dust-tight NEMA type V, or NEMA type XII to meet the JIC specifications of the mass-production industries. Starters are available for 3-phase operation, up to 600 v, 60 cycles.

*Westinghouse Electric Corp., Box 2099, Pittsburgh 30, Pa.*

CONTINUED ON PAGE 254

Photo courtesy of Woodall Industries, Inc.

# A stitch in metal saves *plenty!*

STITCHING with wire is a relatively new way of joining metal to metal, or metal to almost any other material. Since speeds up to 100 stitches a minute are possible . . . and since wire is economical . . . there are tremendous time-and-cost savings compared with other methods of fabrication.

Success of the whole idea hinges largely on special wire. For the wire must be *stiff* to penetrate metal. It has to be *strong*, up to 330,000 psi in tensile strength, to provide a lasting grip. Still it must be *ductile* to take tight 180° bends without cracking or breaking.

Here, at our Worcester Wire Works Division, this unusual wire is produced in several strengths, sizes and finishes to meet all metal stitching requirements perfectly! Here too, the skill and care for which Worcester Wire Works has long been known result in exceptional uniformity—a particularly great advantage for any user of machine-fed wire.

Do you have a problem involving wire? Perhaps, as in metal stitching, a new, specially developed wire is the answer. Maybe you need only some specialized engineering help on the use or fabrication of wire. In any case, Worcester Wire Works stands ready to serve you, to give you the advantage of engineering experience, special skills and techniques that have been over 30 years in the making. It's your standing invitation to out-of-the-ordinary, personalized service in wire.

NS NATIONAL-STANDARD Company MILES, MICHIGAN

**DIVISIONS OF NATIONAL-STANDARD CO.**

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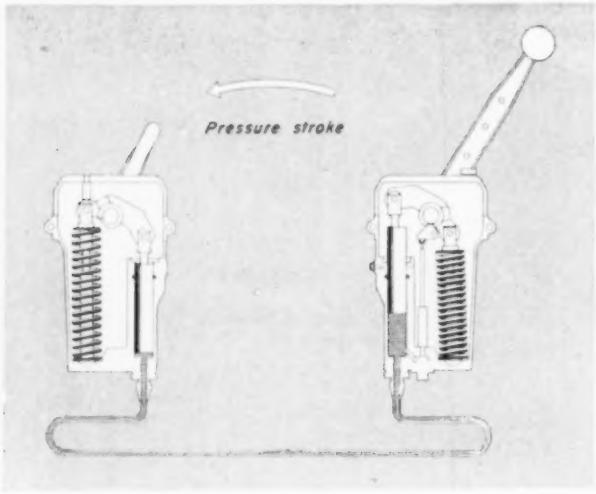
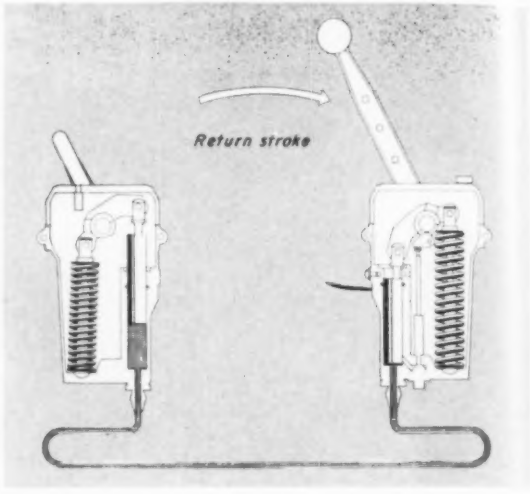
| NATIONAL-STANDARD..*Niles, Mich.* | Tire Wire, Stainless, Fabricated Braids and Tape |
| REYNOLDS WIRE..*Dixon, Illinois* | Industrial Wire Cloth |
| WAGNER LITHO MACHINERY..*Jersey City, N. J.* | Metal Decorating Equipment |
| WORCESTER WIRE WORKS..*Worcester, Mass.* | Round and Shaped Steel Wire, Small Sizes |




# Single Tube, Hydraulic Remote Control System

This hydraulic remote control system is a self-contained system consisting essentially of a hand-actuated transmitter, and a receiver connected by a single tube. This apparatus does not depend on outside sources of power such as electricity or air. The system is filled with hydraulic oil, and because of the oil's incompressibility, any applied force to the transmitter is delivered to the receiver.

On the pressure stroke, which moves the transmitter plunger down and the receiver piston upward, the output equals the input, less friction, which varies with individual installations. The rated output on the pressure stroke is 400 in.-pounds.

On the return stroke of the piston, the spring under pressure in the receiver, forces the oil back to the transmitter as the pressure is taken off. The output on the return stroke depends upon the force of the receiver spring assembly, which is rated at 125 in. lb for standard receivers.

This system makes possible the operation of precision mechanisms free of backlash and sponginess, and gives the operator a certain amount of "feel" of the operated mechanism.

Any temperature change will result in volumetric changes of fluid between the pistons, with a subsequent loss of synchronization. This change in fluid volume is compensated for by moving the transmitter handle through a 7 deg overtravel beyond the zero degree position. This will operate the tripper lever, which opens a valve, venting fluid from the reservoir into the system, or returning excess fluid to the reservoir.

The housing height of the unit is $7\frac{5}{8}$ in.; thickness $1\frac{5}{8}$ in.; approximate weight, aluminum $3\frac{1}{2}$ pounds, bronze, $6\frac{1}{2}$ pounds. Tubing length is up to 300 feet. Rotary motion is 60 degrees. Fittings are $\frac{1}{4}$ in. O. D.

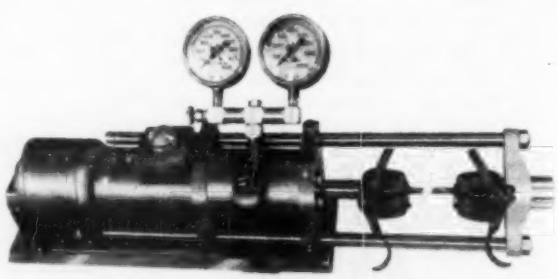
*Sperry Products, Inc., Danbury, Conn.*

# Power Operated, Portable Tensile Tester

This small hydraulic tensile tester, with a capacity of 4,000 lb, has many features of the larger machines, plus the advantages of portability and simplicity of operation. Its applications include: testing spot welds, wire, strip steel, aluminum, textiles, wood, plastics, and prepared test bars.

The pulling action is taken directly from the ram rather than from push-pull construction through a crosshead; therefore friction from lateral pressure is eliminated. The moving grip is suspended from the center of the piston, giving a true axial pull. Both grips are self-aligning. No pressure seals are used. A special design of the grips makes it possible to open both at the same time with one hand, while putting in the test specimen with the other. Grips can be adjusted from 2 to 10 inches.

Overall dimensions are: 31 in. long, 6 in. wide, $11\frac{1}{2}$ in. high. Full ram travel is 3 inches. Total weight is 40 pounds. Other machines are available with larger capacity.



*Cal-Testing Machine Co., 2735 S. Robertson Blvd., Los Angeles 34, Calif.*

CONTINUED ON PAGE 256

★ Above are but a few of the hundreds of valuable functions performed by Greer Accumulators. Greer Bulletin 301 is packed with data, diagrams, and illustrations showing how Greer Accumulators have increased the efficiency and dependability and reduced the cost of various types of power-driven equipment. Send now for your free copy.

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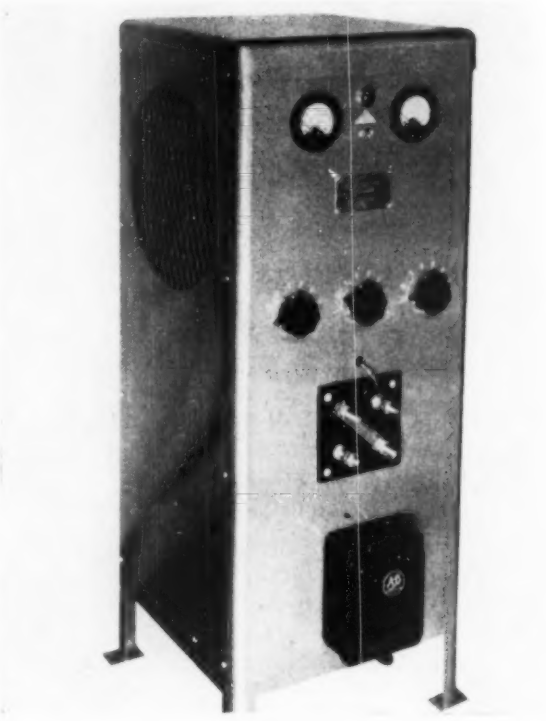
# D-C Power Supply Unit Has Variety of Uses



A new d-c power supply unit has been developed that can be used for electroplating, cleaning, laboratory testing and many other uses where a dependable source of d-c power is required.

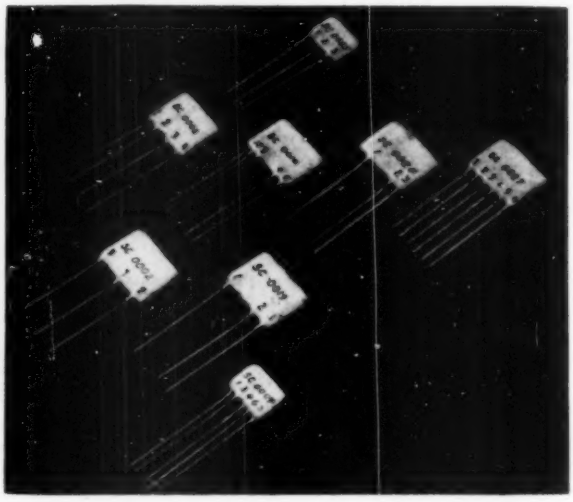
The new unit operates on a-c line voltages of 208 to 230, three phase 60 cycles. It supplies either 500 amp at 3 to 7 v, d-c or 250 amp at 6 to 14 v, d-c. This is a full wave unit with a ripple voltage of approximately 4½ percent under load. The d-c voltage does not drop to zero when a single tap position is changed under load, as has been found in supply units using a three phase half wave rectifier.

The unit is equipped with lektron magnesium copper sulphide rectifiers that can be operated at temperatures from —40 to 284 deg F. The unit is not affected by atmospheric conditions, and over a long period of time has been proved to be rugged mechanically and electrically.

Cabinet size for the d-c power supply is 17 x 17 x 45 in., and includes an a-c contactor with thermal overload relays and an on-off switch; d-c voltmeter; d-c ammeter; three current selector switches; and convenient d-c terminal panel.

*Electronic Rectifiers Inc., 2102 Spann Ave., Indianapolis 3, Ind.*

# Compact, Printed Electrical Circuits



A series of printed electrical circuits combine in a compact unit a complete resistor and capacitor electrical circuit, with external leads for connecting into an electrical or electronic assembly.

Patterns for resistors, capacitors and conductors are printed on vitreous high-dielectric ceramic plates, by a silk screen process, using silver for the conductors, carbon graphite or other resistance materials for the resistors, and employing the dielectric properties of the ceramic for the capacitors. The patterns are permanently bonded to the ceramic surface by controlled curing, and protected from both abrasion and humidity by a tough plastic covering.

One printed circuit is said to replace from two to six individual components with consequent reduction of soldered connections of 25 percent to 80 percent depending upon the circuit. They save space, and reduce weight.

The model SC 0027 with six leads, shown at the far right in the illustration, measures 1⅛ in. wide, $\frac{5}{32}$ in. thick, and $\frac{13}{16}$ in. high, not including the length of the leads.

*Stupakoff Ceramic & Mfg. Co., Latrobe, Pa.*

A DEPOSITED CARBON RESISTOR, known as the carb-ohm, is being manufactured for high frequency applications, particularly where high values of resistance are essential, or power dissipations up to 2 w are required. They are also used for computor network, and for electronic equipment subject to extremes of temperature. Hermetically sealed in glass, or clad in a humidity impervious casing. Ratings from ⅓ to 2 w with a resistance range of 20 ohms to 200 megohm. Phaostron Co., 151 Pasadena Ave., South Pasadena, Calif.

CONTINUED ON PAGE 258

## Customer Reports:

# "Considerably Less Waste Metal" with Asarco Continuous-Cast Bronze

Servel, Inc., Evansville, Indiana, manufacturer of electric refrigeration compressors, has found a twofold benefit in its use of Asarco Continuous-Cast Bronze: Improved performance of a production line item because of superior dispersion of constituents in the bronze; a sharp reduction in material cost due to lower reject rate and less short-end scrap.

This Asarco customer uses Continuous-Cast Bronze to fabricate a shaft sealing member which runs against hardened steel with very little lubrication. The constituents of the bronze must be distributed throughout its cross-section *with absolute uniformity* to preclude failure of the seal due to rubbing. Individual casting and chilling of these parts has been given up in favor of Continuous-Cast Bronze.

The unique Asarco casting process gives you bronze rods, tubes and shapes with properties up to 100% better than those of sand-cast bronzes . . . with no porosity, no hard or soft spots. Asarco Continuous-Cast Bronzes are ideal for use on automatic screw machines.

You can get Continuous-Cast Bronzes made to order in a wide variety of alloys . . . in standard lengths of 12′ . . . lengths 5′ to 12′ on request . . . lengths 12′ to 20′ by special arrangement.

216 sizes of standard Asarcon 773 bronze (SAE 660) are stocked in 105″ lengths by distributors across the nation . . . in diameters of ½″ to 5″, cored or solid. This bronze will be cut *long or short* to suit your needs.

Free illustrated catalog describing properties, sizes, weights, etc., is available on request. Use coupon below.

These photomicrographs demonstrate the superior dispersion of constituents in continuous-cast alloys . . . also their freedom from porosity and other metal faults. (Alloy of 75% Cu, 5% Sn, 20% Pb shown here).

ASARCO CONTINUOUS-CAST RODS · TUBES · SHAPES ®

West Coast Sales Agent:
KINGWELL BROS. LTD., 444 Natoma Street, San Francisco, Calif.

**American Smelting and Refining Company**
OFFICES: Perth Amboy Plant, Barber, New Jersey
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Please send me a free copy of the 12-page catalog "Asarco Continuous-Cast Bronze."

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## Pressure Filled Metallic O-Rings for Static Seals

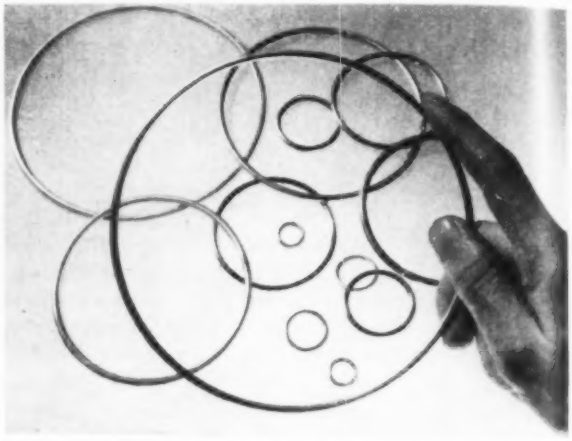
A new answer to static sealing requirements is said to have been found in the metallic O-ring, an easily installed, hollow metal tubing filled with inert gas at 600 psi. These rings give positive metal to metal static seals wherever problems of heat, pressure, corrosive liquids, or gases are involved.

The metallic O-rings are dimensionally stable under heat or cold, are not affected by oils, gases, or aromatic mixtures. They can be installed in present ring grooves, in free machined recesses, or with a special compression limiting device that can be incorporated in the rings. It is also possible to install them without grooves or recesses.

These rings will hold against pressures as high as 20,000 psi, and withstand temperatures limited only by the physical limits of the metal. If not damaged structurally, the same ring can be used over again and still give a perfect seal.

The rings have been used successfully in high compression diesel engines, air compressor and vacuum equipment, all types of fuel and exhaust systems, retractable undercarriages and other hydraulic equipment, as well as marine, automotive, and specialized aircraft applications.

Standard rings of stainless steel, or of mild steel cadmium or nickel plated, are available in sizes ranging from 11/16 in. to 40 in OD. in increments of 1/16 inch.



*United Aircraft Products Inc., 1116 Boleuder Ave., Dayton, Ohio*

## Timed Operations Preselecting Unit

The timed operations Preselector is a new type of timer that allows for adjusting the timing of each cycle of a process independently. It can be used to energize a number of electrical devices during a single cycle of a process.

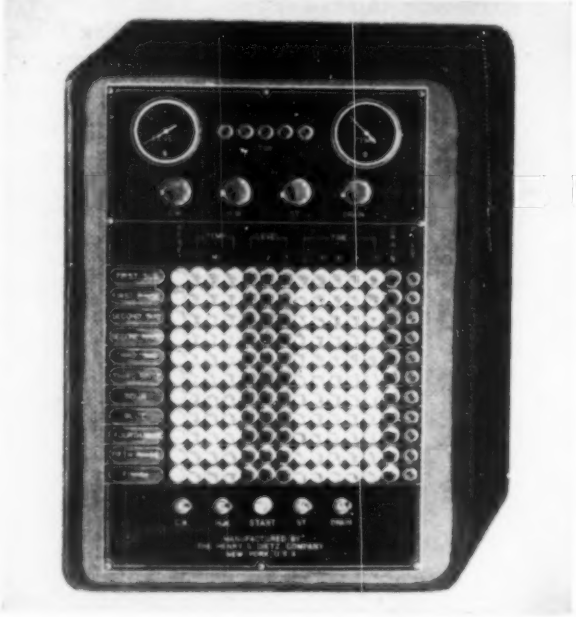
The unit illustrated is for use on laundry machinery. It selects the time, temperature, and water level of each of eleven wash cycles. It has contacts available to give pilot light indications of circuits, and means of starting and stopping the washer motor.

The Preselector consists of a single synchronous motor timer which delivers a repetitious fixed time impulse. Any multiple of this impulse can be preselected by pushbuttons for the desired time interval of each cycle. Each row of pushbuttons represents a cycle of operation. Therefore, it is possible to change the time sequence of any one cycle without affecting change in any of the other cycles. There is no limit to the number of cycles, the length of the time sequence, or the number of circuits that can be handled.

This unit is an electrically operated device using no cams, clutches, or other mechanical parts subject to wear. It may be used from any voltage, either a-c or d-c.

The units are particularly suited for processes where automatic operation with much flexibility is desired.

*Henry G. Dietz Co., Coral Designs Div., 12-16 Astoria Blvd., Long Island City 2, N. Y.*



BY USING A COLD CATHODE TUBE of unlimited life, an electronic pilot relay is capable of controlling large values of current and power with a current flow of 2 millionths of an ampere. This small flow of current permits delicate mechanisms to control large electrical currents. The relay will operate over any input resistance from a dead short to 10 megohms, with leads of unlimited length. Using 115 v, 60 cycle, the relay consumes 2 watts. The pilot relay is housed in an 18 gage steel case. A visible jewel indicator permits visibility for off/on operation while the relay case is locked. Haledy Electronics Co., 57 William St., New York 5, N. Y.

CONTINUED ON PAGE 260

# Some Things Are WORSE THAN STRIKES

*This editorial which appears in McGraw-Hill publications was written just prior to the resignation of Charles E. Wilson as Director of Mobilization. The principle it discusses is of basic and continuing importance in our struggle to maintain economic and personal freedom in America.*

**It is to be hoped that the managements of the steel industry will resolutely resist the efforts of the national Wage Stabilization Board to force them to establish the union shop in their plants. In essence, the union shop means compulsory union membership.**

They should resist not because of any financial advantage to the owners of the industry. There would be none. They should resist out of a decent regard for those ideals of our country which we are now fighting in Korea to protect. Moreover, their resistance would, as a matter of fact, benefit the leaders of the organized steel workers by protecting them from the certain and bitter fruits of their "victory" in getting the government to impose the union shop on the steel industry. Their successful resistance would also prevent Premier Stalin and his co-workers from enjoying a hearty laugh at our expense.

### Fun for the Russians

This is why the Politburo would find the establishment of the union shop in the steel industry, at the behest of the Wage Stabilization Board, so profoundly amusing. We are fighting in Korea because we believe that armed aggression, promoted by Russia, menaces our freedom. And we are spending hundreds of billions of dollars here at home for armament to protect our freedom at other danger points. When this rearmament program is threatened by a crippling strike, the federal government through its Wage Stabilization Board proposes to buy off the threat by plowing under a vital element of that freedom which we are trying so desperately to preserve.

When the union shop is adopted through voluntary agreement, as it has been in cases covering millions of workers, it deeply undercuts the freedom of the individual. To hold his job he is required to join the union and support it financially whether he wants to or not. In the case of such voluntary agreement, however, the government takes no direct part in thus destroying the freedom of its citizens. It is essentially a private transaction.

### Tyranny is the Word

But in the steel case the federal government becomes a party to a direct attempt to impose the union shop. Instead of protecting its citizens in their right to earn a livelihood, the government forces certain of them to join and support a private organization which they have clearly indicated they do not want to join. This they must do to hold their jobs. Tyranny is the accepted designation of government coercion of this kind.

It may be objected that the Wage Stabilization Board merely recommends the union shop, does not order it. This was also true of the action recently taken by a President's Emergency Board, which also "recommended" that working agreements between the

railroads and about a million non-operating railroad employees include a provision for the union shop. A government recommendation, however, can easily be given much of the force of an order, particularly by the calling of a strike to "uphold the hand of the government."

It seems entirely clear that in trying to impose the union shop on the steel industry the Wage Stabilization Board has completely lost its bearings. It was set up to handle labor problems to tide over an emergency. Now it comes up with a revolutionary modification of labor relations in the steel industry which, if adopted, would become a permanent part of the institutional machinery of the industry.

### "Too Much Like Hitler"

Early in World War II an effort was made to have the federal government order the union shop for a group of organized coal miners. President Franklin D. Roosevelt, who will go down in history as one of organized labor's greatest champions, blocked it. "That," he said, "would be too much like the Hitler methods toward labor." But now, with supreme irony, the federal government fosters this Hitlerlike method toward labor ostensibly to advance our conflict with Stalin.

In persuading the Wage Stabilization Board to sponsor the union shop for steel workers, there is every reason to believe that the union leaders have trapped themselves. If the government imposes the union shop, a next step clearly becomes necessary. This is government regulation of the union in order to provide a modicum of protection for the minority that would be forced by the government to join against their will. It could be that for a time the government would ignore this obligation. But, having granted the union the power to eliminate the minority, it would sooner or later be forced to regulate the use of that power. Thus free collective bargaining and freedom itself would be the losers.

### An Issue of Basic Principle

Resistance to a government-sponsored union shop for the steel industry is bound to bring harsh denunciation both from the administration and union leaders who have teamed to back it. Not only does the union shop relieve the union leaders of the problem of recruiting members, it also eliminates a group of workers that they stigmatize as "free riders"—namely, those who work for companies which have a working agreement with a union but do not join the union. In the basic steel industry about 10 per cent of those who work for companies with union agreements are not members of the union. Such a small percentage of non-members is obviously no threat to the "security" of the union, although that is what the drive for the union shop ostensibly is designed to protect.

In the reporting of the present labor dispute in the steel industry virtually all of the attention has been focussed on the handling of the issue of a wage increase and how large it should be. This, to be sure, is vitally important. Mobilization Director Wilson has said it is "a serious threat to our year-old effort to stabilize the economy." But certainly of comparable importance is the tremendous issue of principle raised by the government's backing of the union shop for the steel industry.

**If the position of the Wage Stabilization Board on the union shop prevails, our government will have blunted the arms we are forging to fight for our freedom abroad by undermining a major bulwark of our freedom right here at home. At this critical time in the struggle to preserve and protect our freedom such a subversive course should be resisted to the limit.**

***McGraw-Hill Publishing Company, Inc.***

# NEW CATALOGS AND BULLETINS

## A Reader Service To Help Keep You Up-to-Date

(1) **PLASTIC PAINT** — The Corrosite Corp., Bulletin 201, 8 pp. Gives characteristics, applications, and methods of use of the corrosion resistant, protective plastic paint. Describes methods of applying the paint, and outlines uses in railroad, chemical processing, petroleum, marine, public utilities, and other industries.

(2) **LONG-WEARING PARTS** — Haynes Stellite Co., Bulletin, 24 pp. Entitled, "Long Wearing Machinery Parts," it shows the variety of cast and wrought alloy parts now being used to solve abrasion, corrosion, and high temperature problems. Parts described are made of cobalt, iron, and nickel-base alloys. Includes more than 60 blueprints, tables, and photographs.

(3) **AIR SCALE**—Fluid Controls Co., Inc., Catalog 100-A, 8 pp. Describes how the air scale weight transmitter operates, and how it may be used as an individual weighing unit, or as an integral part of a process control system. Contains cross-section view, calibration curves, and diagrams of typical applications.

(4) **POWER DRIVES**—Sterling Electric Motors, Inc., Catalog 174, 20 pp. Has complete descriptive information on variable speed drives, geared motors, and constant normal speed motors in drip-proof, splash-proof, totally enclosed, and pipe ventilated designs. Contains many sectional, cross-sectional, and colored illustrations.

(5) **O-RING SPECIFICATIONS** — Precision Rubber Products Corp., Bulletin, 10 pp. Called, "Engineering Data On Army-Navy O-Ring Hydraulic Packings," it gives information on O-ring sizes, applicable groove dimensions, and compounds. Contains in charts, information on AN-6227B, AN-6230B, AF-934, AN-6290, MS-29512, and AN-123586 through 124034, plus other compounds.

(6) **AUTOMATIC REGULATING VALVES**—Spence Engineering Co., Bulletin 700, 4 pp. Describes design features, and has a large cutaway illustration of a typical pilot-operated regulating valve with detailed explanation of five design features. Also shows how the control function can be changed by using a different sensitive pilot.

(7) **FILM TYPE HEATING ELEMENTS** —Electrofilm Corp., Booklet. Covers the uses, methods of application, mechanical, thermal, and electrical characteristics of this type of heating element. Material is an electrically conductive plastic that gives uniform heat distribution, and maximum heat transfer. Many applications covered.

(8) **SELENIUM RECTIFIERS**—Fansteel Metallurgical Corp., Bulletin RDP-112, 16 pp. Contains illustrations of the many types of rectifiers made in 10 standard sizes, 8 round, and 2 rectangular. Covers terminology, cell sizes, and ratings, protective coatings, typical circuits up to a 3 phase bridge, circuit formulae and constants, and graphs.

(9) **CONTROL OF MEASURING INSTRUMENTS** — Minneapolis-Honeywell Regulator Co., Catalog 5000, 28 pp. Describes the principal instruments, control devices, and related components. Gives specifications of about 100 measuring and control instruments, and valves. Also includes differential controller, and Tel-O-Set controller.

(10) **STROBOSCOPES** — General Radio Co., Booklet, 8 pp. Covers the complete line of stroboscopes, how the unit works, plus specific applications of the different instruments. Units described are the strobotac, strobolux, strobolume, microflash, and flash synchronization contactor.

(11) **THERMOHMS**—Leeds & Northrup Co., Catalog EN-S4, 26 pp. Covers the line of general purpose and specialized resistance thermometers that detect temperatures between —325 and +1,000 F. Contains 5 page tabular guide telling what thermohm to use for application in ceramics, chemical, food and drug, glass, iron and steel, and other industries. Contains photos of each unit.

(12) **COMPOUNDING RESINS**—B. F. Goodrich Chemical Co., Bulletin G-8, 16 pp. Contains technical data on the compounding of Geon 101 and 101-EP straight polyvinyl chloride resins. Discusses materials and factors used in compounding the resins, plus some applications.

(13) **PYROMETER SUPPLIES**—Minneapolis-Honeywell Regulator Co., Catalog 100-4, 42 pp. Furnishes technical data on the application and use of thermocouple pyrometric supplies. Contains information on all assemblies as well as parts. Exploded view of all assemblies, plus special molten metal, penal type, and midget thermocouples.

(14) **AC INDUCTION MOTORS**—Westinghouse Electric Corp., Bulletin B-4731, 20 pp. Now made in ratings up to 700 hp, the design and application features of the life-line motors are described. Illustrations show construction of motor frames, end brackets, stators, rotors, and bearings.

(15) **PUMP CASTINGS**—Meehanite Metal Corp., Bulletin 36, 20 pp. Contains many photographs of various types of pump castings, plus tables and charts showing the property evaluations made from tests on wear, resistance to acid corrosion, and impact. Cross-section views of pump castings and impellers.

(16) **OSCILLATING CONVEYORS**—Link Belt Co., Booklet 2444, 24 pp. Includes dimensions, weights, and capacity and horsepower charts on torsion mount oscillators for heavy duty, and the flexmount oscillators for lighter-duty applications. Illustrations show parts of conveyors as well as the handling of different products.

(17) **AIRCRAFT EQUIPMENT**—Jack & Heintz, Inc., Bulletin 145, 4 pp. Contains capsule descriptions of their rotomotive equipment for aircraft. Model data given on line of gas turbine and reciprocating

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**(18) FLOW METERS**—Bristol Co., Bulletin F1605, 40 pp. The series 500 line of instruments is described. Included are instruments for integrating, recording, indicating, automatic controlling, and telemetering the flow of steam, water, air, gas, oil, solutions, and other fluids. Both mechanical and electrical type meters described in full range of models, and variety of uses.

**(19) HARD RUBBER & PLASTICS**—American Hard Rubber Co., Handbook, 80 pp. Includes: tables of properties, tolerances, weights, design techniques, inserts, assembly, machining and finishing of hard rubber, and other molded plastics such as saran, polyethylene, acrylics, acetates. Also has illustrations and diagrams.

**(20) ELEVATING TABLES**—The Raymond Corp., Bulletin 206, 4 pp. Describes the complete line of hydraulic elevating tables, showing models which can be used for die handling, or work positioning, and others for strip and sheet feeding operations. Tables come in a range of capacities from 2,000 to 20,000 lb. with various ranges of elevation.

**(21) LOAD CELLS**—Automatic Temperature Control Co., Inc., Bulletins 62 and 65. Bulletins describe and illustrate the application of the torsion bar load cells, and the cantilever beam load cells. The cells measure force in tension or compression, thrust, torque, or weighing. They change a mechanical force into a linear electrical signal to be fed into servo recorders and indicators.

**(22) SPRINGS & CIRCULAR FORGINGS**—American Locomotive Co., Bulletin RS-1, 12 pp. Covers the helical compression springs, helical extension springs, belleville disk springs, and ring forgings. Includes the volute springs, made of flat steel wound in the form of a cone so that the coil telescopes. Formulas for computing spring dimensions, plus design recommendations and specifications.

**(23) FLEXIBLE SHAFT DRIVES**—Elliott Mfg. Co., Catalog 210, 6 pp. A line of flexible shaft unit drives in ranges of heavy, medium, and light duty, and the drill shaft unit. The heavy duty may be used for power take-offs and low operating speeds, and has core diameters from 1/8 to 1/4 inch. The medium drive, used on any power source, has core sizes from 5/16 to 5/8 inch. The light duty has a 5/8 in. core, and the drill shaft a 1/4 in. core.

**(24) PRECISION CASTING** — Casting Engineers, Bulletin 17, 4 pp. Explains cost reduction through investment casting. Most castings produced within limits of ± 0.004 in., with a wide variety of alloys possible in stainless steel, tool steel, high speed steel, and most non-ferrous metals. Illustrations show shapes possible.

**(25) TEFC MOTORS** — Allis-Chalmers Mfg. Co., Bulletin 51B7225, 6 pp. Describes the type APZ totally enclosed, fan-cooled motors, which, because of the lack of internal air passages and dirt catching pockets, makes the motor easy to keep clean. Large, two page, cutaway view of motor. Complete specifications.

**(26) PUSH-PULL CONTROLS** — Southwest Products Co., Catalog 1551, 8 pp. Contains detailed prints and complete specifications on remote, mechanical, push-pull controls of the compression and tension type with a flexible inner element. Three sizes described with a compression ultimate load from 1,250 to 3,050 lb, and tension range from 960 to 3,900 pounds.

**(27) HIGH FREQUENCY GENERATORS**—Bogue Electric Mfg. Co., Bulletin 440, 8 pp. Has illustrations and specifications on a complete line of 400 cycle generators and motor-generator sets available from 100 w to 600 kw output, either single or three phase. Input current can be alternating, single or three-phase, or direct.

**(28) HYDRAULIC CYLINDERS**—Rivett Lathe & Grinder, Inc., Catalog 105, 12 pp. Illustrated and described are 108 different models of hydraulic cylinders, each in 10 bore diameters. Working drawings and specifications for each model and size cylinder, both standard and cushioned types, standard and 2:1 oversize rod, single and double end rods. Pressures to 1,500 psi; special cylinders to 3,000 psi.

**(29) METALIZED PLASTICS** — Coating Products, Bulletin, 6 pp. Gives an assortment of metallic acetates and polystyrenes with a color chart showing the complete range of colors and finishes. The metalized plastics can be easily formed and folded, die-cut, stitched or sewn, laminated or glued, embossed and printed upon.

**(30) PORCELAIN PRODUCTS** — Star Porcelain Co., Bulletin 1251, 24 pp. Describes the various ceramic bodies which are used principally in the manufacture of electrical and electronic equipment. Gives design suggestions, plus tables containing complete data on physical properties and application information. Illustrations showing engineering, production, and research.

**(31) FACTS ON PLASTICS**—The Richardson Co., Bulletin, 22 pp. Entitled, "Facts About Plastics, Molded and Laminated," it covers such points as: what plastics can do; limitations; thermosetting vs thermoplastics; how laminated plastics are made; applications; ways of molding plastics; consumer and industrial applications; and other points. Many illustrations.

**(32) ELECTRICAL & LUBRICATING PRODUCTS**—Trico Fuse Co., Folder FLB 300-C, 8 pp. Describes the powder-packed renewable fuse, the one-time and plug fuses, fuse pullers, kliplok clamps for fuse clips, test clamps, and lubricating devices. Chart shows types, sizes and suggestions for application of lubricating units.

**(33) ABEA FLOW METER**—Fischer & Porter Co., Bulletin 10529, 8 pp. Gives full specifications, capacities, sizes and dimensions for flow-rate meters, indicating and transmitting flow meters, bull's eye flow indicators, laboratory test kits, and other sight flow indicators. Has illustrations and engineering drawings.

**(34) WIRE ROPE ASSEMBLIES**—Macwhyte Co., Catalog 5201, 22 pp. It illustrates and gives detailed specifications for wire rope with fittings permanently attached. Used for operating controls, as a part of machinery and equipment, and for slings and hoists.

**(35) PERMANENT MAGNETS** — Carboloy, Bulletin PM 100, 20 pp. Completely illustrated, it contains pull curve and size information in tabular form on stocked types of Alnico permanent magnets, both cast and sintered, plus size and application data on holding assemblies, including sheet steel separators, magnetic retrievers, and stands. Also, a list of available patterns for various sizes.

**(36) INDUSTRIAL COATING TERMS**—The Sherwin-Williams Co., Booklet G-512, 16 pp. Called a "Glossary of Industrial Coating Terms," this booklet contains over 200 definitions of terms commonly used in industrial products finishing.

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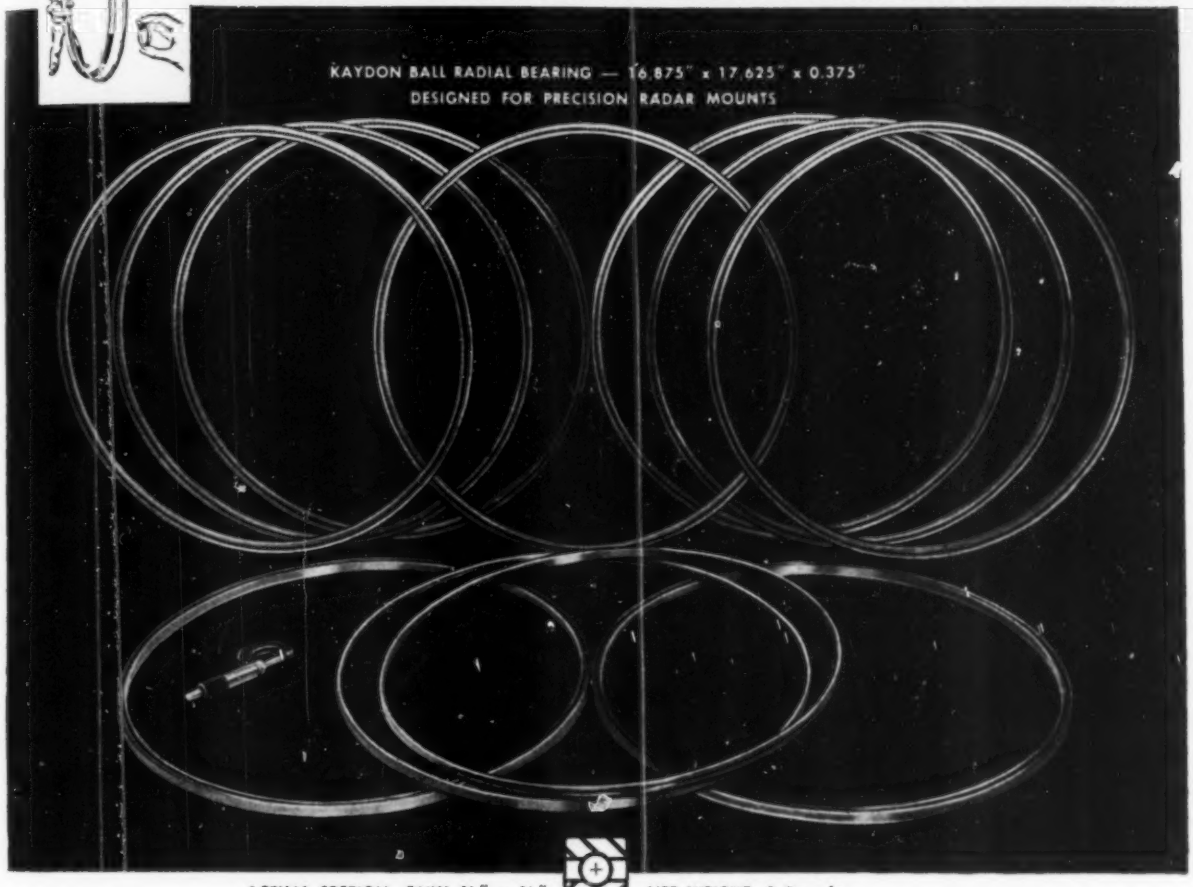
Contact KAYDON Muskegon

FOR ALL TYPES OF BALL AND ROLLER BEARINGS: 4" BORE TO 120" OUTSIDE DIAMETER




ACTUAL SECTION: ONLY 3/8" x 3/8"

NET WEIGHT: 2 Pounds

# WORLD'S THINNEST BEARINGS

## THIN AS A WEDDING RING... WITH THE PRECISION OF FINE WATCH PARTS

Proportionately, that's an understatement! A wedding ring as big as 17.625" outside diameter would be about four times as thick as the actual 0.375" section of these thin KAYDON bearings... and even the finest watch parts, enlarged proportionately, probably would not have the precision tolerance to which these bearings are consistently finished. • These are by far the thinnest ball bearings ever made in this large diameter. KAYDON has developed the facilities and special techniques vital to such precision production.

Precision miracles in extremely large bearings of unusually thin section have become routine achievements at KAYDON. In addition to unique thinness that conserves space and weight, other outstanding features have been embodied in many special KAYDON bearings ... for instance: Flame hardened bearing races drilled, tapped and gear-cut by the KAYDON process eliminate costly auxiliary parts, help improve machine design and performance, and make possible more compact, lighter machines of greater capacity.

For unusually large, light weight, thin section bearings, contact KAYDON of Muskegon.

KAYDON Types of Standard and Special Bearings:
Spherical Roller • Taper Roller • Ball Radial • Ball Thrust
• Roller Radial • Roller Thrust • Bi-Angular Bearings

THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

PRECISION BALL AND ROLLER BEARINGS

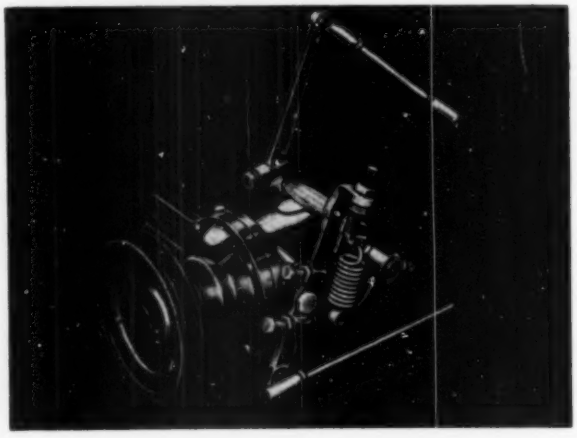
## Governor Used On All Industrial Engines

A new governor gives instant variable speed selection and correct engine control at any speed setting within 1200 to 2600 rpm, with higher speeds possible by an adjustment of the pulley.

It has been found to give accurate speed control for all industrial and farm engines, and is used on corn shellers, drag lines, hoists, trucks and tractors with power take-offs.

Known as the long range universal governor, it operates equally as well at variable speeds or at constant speeds. For variable speed operation, a quadrant or similar manual control sets the governor to desired speed. Constant speed operation is possible by locking the speed control lever at fixed speed

The governor is easily installed and can be mounted on either side of the engine. Speed control lever, carburetor control lever, and mounting flange fit either side of the governor.



*The Pierce Governor Co., Inc., Anderson, Ind.*

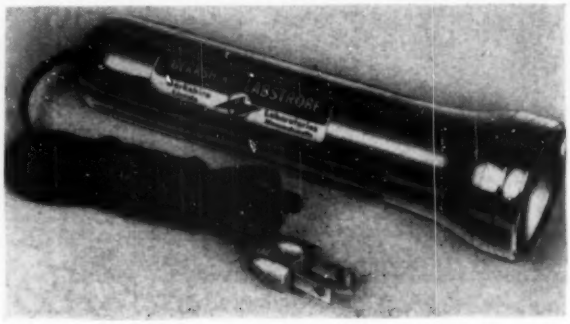
## Small, Lightweight Stroboscope Unit

The Labstrobe, model 18 is a small, light, stroboscope unit, giving 60 flashes of light per sec when connected to an ordinary 60 cycle a-c power line. The lamp is a standard neon bulb having long life and easily obtainable when a replacement is needed.

The duration of the flashes is short enough to permit the reading of a newspaper clipping while rotating at 1800 rpm.

The labstrobe is useful for determining the speeds of rotation of motors, machines, phonograph turntables and other objects. The instrument is housed in a chromium plated case, and is the same size as a standard two-cell flashlight. An aluminized reflector directs the light forward to increase the illumination provided.

Specifications for the model 18 labstrobe: power source, 115 v, 60 cycle a-c; power consumption less than 1 w; flashing rate, 60 cycles per sec, determined by line frequency; flash duration, approximately 100 microseconds. This is measured at 50 percent of peak intensity.



*Berkshire Labs., 510 Beaver Pond Rd., Lincoln, Mass.*

## Explosion Proof Solenoid Valve Unit

Modifications of the X5 type valve have been made to meet all of the Underwriters Laboratories' requirements for Class I, group D explosion-proof construction.

The new details include: a top nut that has increased thread engagement and increased leakage path; a cap that is machined from solid steel and brazed to the coil housing; and a body giving greater thread engagement with the flange and is machined to give a lap and rabbet joint with the coil housing. The coil housing is machined from heavy wall steel tubing and fits the body of the valve with an average clearance of less than one thousandth of an inch.

Small size and light weight are made possible by closely held fits which permit reduced joint lengths, steel construction which reduces wall sections, and eliminates the bolted flange type of construction. The overall height for the 2 way valve is 3 in., and the dia. is $1\frac{3}{4}$ inches.

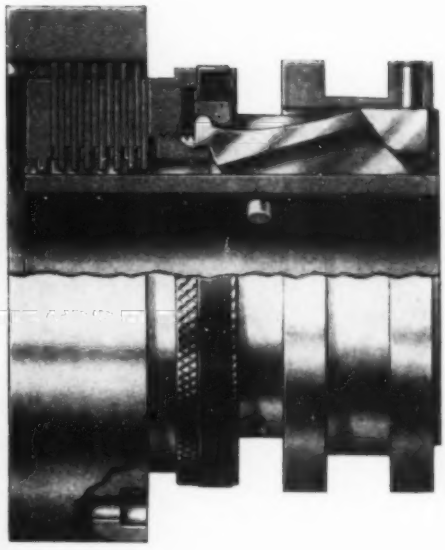
As the port and mounting hole locations are the same, this valve is interchangeable with the standard line of valves. The valve may be mounted in any position; the electrical conduit may be rotated to any position, and most of the standard wide range of orifice sizes and pressure ratings are available. Valves can be supplied as two-way, normally open or closed, and three-way normally open, closed, or directional flow.

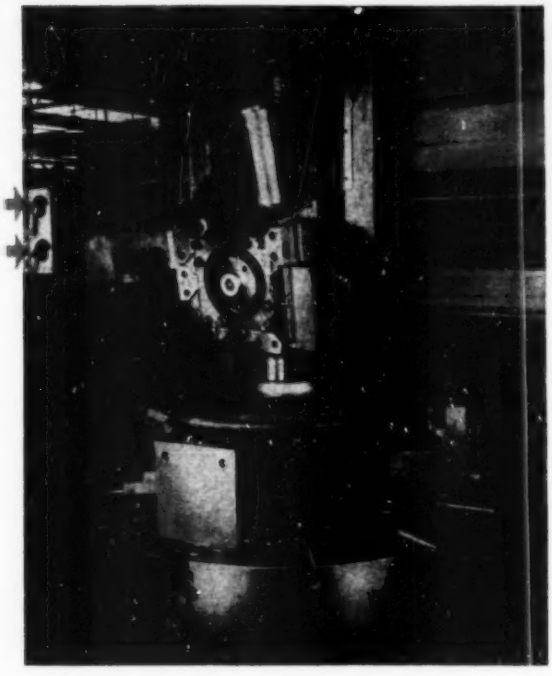
Other features: low power consumption, ten watts; soft leakproof spring loaded seals; variety of port locations in the $\frac{1}{8}$ and $\frac{1}{4}$ in. size; stainless steel internal parts; most types are available with metering; valves can be supplied for a-c or d-c in a wide range of voltages and frequencies.

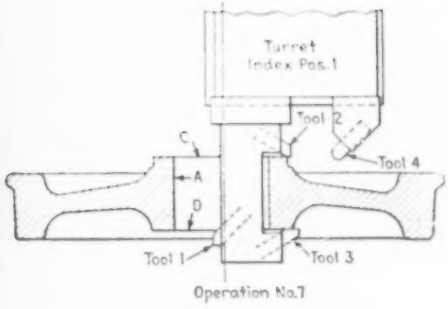
*Skinner Chuck Co., Norwalk, Conn.*

CONTINUED ON PAGE 262

# MAXITORQ
## keeps good company








**Turret index Position 1, the rough boring is performed. Tool set-up faces the hubs. (There are 4 index Positions.)**

THE BULLARD COMPANY, outstanding machine tool manufacturer, selected Maxitorq floating Disc Clutches for power transmission control in its famous Man-au-trol vertical lathe.

A Bullard engineer says, "Two No. 22 Maxitorq Clutches (see arrow) are used to automatically engage the cross-feed and down-feed drives for Angle Turning. In order to maintain accuracy, no slippage can be tolerated; the No. 22 Maxitorq Clutches are suitable for this application." In the job shown 12 carbide tools machine both sides of a Diesel engine wheel in 64 minutes, automatically. Former method required 4 hours.

If you have clutch problems look to Maxitorq... 8 standard sizes to 15 H.P. @ 100 r.p.m., wet or dry, single or double. Also in Automatic Overload Release type. All clutches manually adjusted, taken apart or assembled. Variety of special Driving Cups available. Complete engineering recommendations on request. Join our many "Good Company" users.

**SEND FOR CATALOG No. PE-5**

**THE CARLYLE JOHNSON MACHINE COMPANY**
**MANCHESTER • CONNECTICUT**

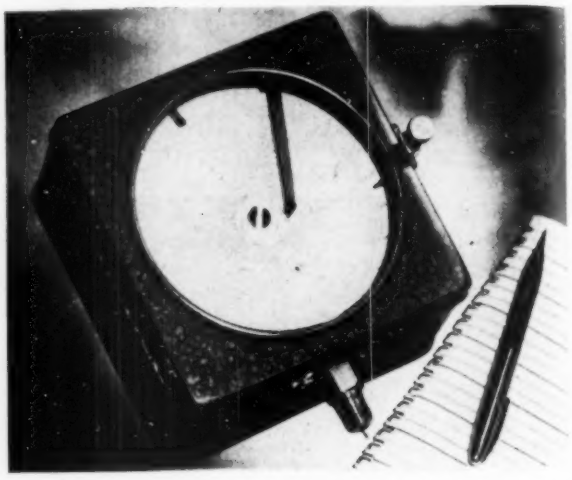
## Miniature Measuring and Recording Device

A compact instrument, known as the type 3-B minicorder, used for measuring and recording low pressures, has been designed for chart records as low as 0 to 10 in. head of water pressure. Other charts are available with ranges to as high as 0 to 60 psi. Overall dimensions are $5\frac{1}{4}$x$5\frac{1}{4}$x$2\frac{1}{4}$ inches. Weight is 2 pounds.

The minicorder has a calibration adjustment that allows for range adjustment at any point on the chart, for exact setting.. It is possible to calibrate the unit in such combinations as: inches head of water, pressure or vacuum; ounces per sq. in.; inches head of mercury, pressure or vacuum; feet head of water pressure or vacuum; psi; absolute pressure; feet head of any liquid pressure not corrosive to brass or stainless steel; compound pressure and vacuum using any unit of measurement; plus or minus altitude, compound; partial or limited scale charts.

The measuring elements are enclosed in an all metal case, and rubber gasketed for protection from dust and moisture. These elements consist of a series of brass bellows for liquids and gases not corrosive to brass. For other ranges, stainless steel may be used. These bellows provide sufficient power to move the pen across the chart without the lag or drag common to low pressure instruments.

Suggested applications are: fan ventilating systems; partial and complete vacuum systems; combustion systems; manufactured gas distributing systems; recording liquid levels in tanks, or reservoirs; high pressure draft gages, and operations requiring increased ambient air pressure.

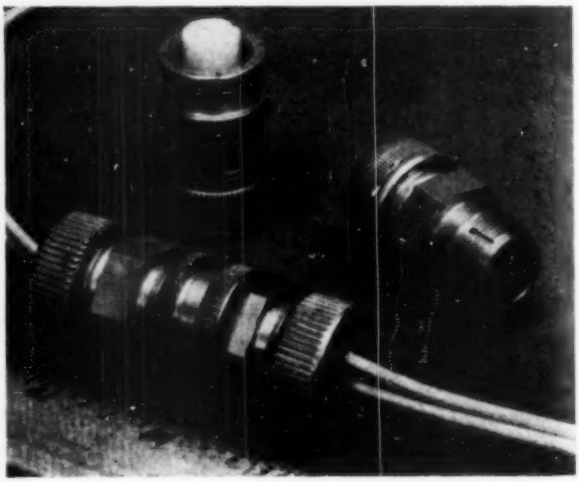


*The Dickson Co., 7420 Woodlawn Ave., Chicago 19, Ill.*

## New Line of Lightweight Electrical Connectors

A complete line of new lightweight electrical connectors, designed to meet special requirements of temperature, corrosion, and vibration, is now available for general use on all electrical equipment. The connector will be furnished in 17 shell sizes, conforming to AN sizes 8-36 inclusive, and can be furnished for cord connections, shielded assemblies, and bulkhead or box mountings.

This new lightweight connector is said to introduce an unusual method of assembly that allows for unlimited wiring arrangements. Its design eliminates clamps, saves space, facilitates harness assembly, and allows easy changes in wiring arrangements. In assembly, a production advantage is that the terminals can be removed from the block to solder, or the wire or wires crimped to the end of the terminal, eliminating the difficulty of making a connection in the confined space of the connector shell. This also will eliminate the problem of twisting slack wire into the connector upon completing the assembly. May be used in all applications.



*Titeflex, Inc., 500 Frelinghuysen Ave., Newark 5, N. J.*

THREE NEW POLYESTER RESINS are said to withstand prolonged temperatures up to 500 F without losing strength. Reinforced by glass cloth, the resins will give flexural strength values from 30,000 to 35,000 psi at 500 F. The three resins will be: a general purpose resin; a fire resistant resin; and a crystalline resin for impregnating mat or cloth. American Cyanamid Co., 30 Rockefeller Plaza, New York 20, N. Y.

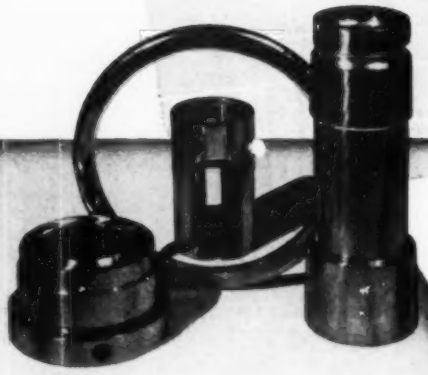
A NEW THRUST AND RADIAL BEARING DESIGN for instruments and small mechanisms comes in two standard sizes of: $\frac{3}{64}$ in. dia by $\frac{3}{16}$ in. long; and $\frac{1}{16}$ in. dia by $\frac{1}{4}$ in. long. Shafts are of pivot and shaft tool steel, and heat treated. Shaft ends are radiused instead of chamferred to prevent scoring of the bearing surface. High finish gives low friction. Welton V. Johnson Engineering Co., Inc., Summit, N. J.

CONTINUED ON PAGE 264

# part of every quotation..

"Policies of management, way of doing business, traditional attitude towards the customer—these are no less a part of every quotation than are figures. Often these so-called intangible factors become far more important to the purchaser than the price."

***All the facilities, equipment and resources of the Bunting Brass & Bronze Company are created to serve the buyer as well as to manufacture a product. Ask any Bunting customer.***



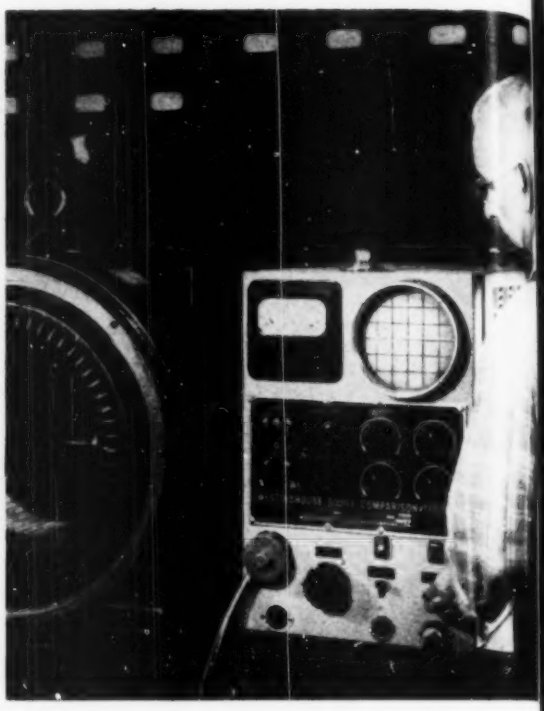
The sleeve bearing is not complex in structure; it conforms readily to design requirements; it is easily installed. Cast Bearing Bronze is the most adaptable of all sleeve bearing materials; it possesses excellent anti-friction properties. With proper film lubrication, its coefficient of friction is as low as can be obtained with any other bearing type. A successful Bunting Bronze bearing installation is readily attainable. We ask the opportunity to work with you, and to quote on your requirements.

**Bunting**®

BRONZE BEARINGS • PRECISION BRONZE BARS • BUSHINGS

THE BUNTING BRASS & BRONZE COMPANY • TOLEDO 1, OHIO • BRANCHES IN PRINCIPAL CITIES

## Industrial Electronic Surge Comparison Tester



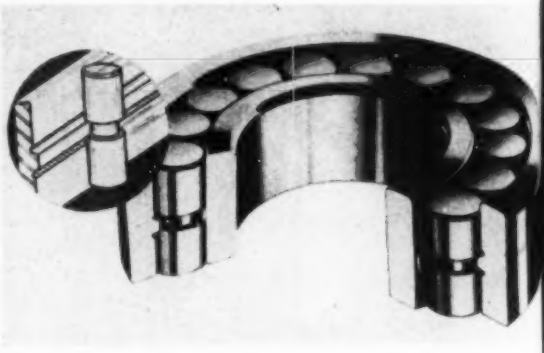
This industrial electronic surge comparison tester, available in either mobile or portable models, is used to locate insulation faults and wind dissymmetries in motors, a-c and d-c generators, transformers, and coils. Compact and movable, it has adequate surge voltage characteristics for most insulation tests. The tester may be used for both manufacturing and repair work.

The tester simultaneously tests turn-to-turn, phase-to-phase, and coil-to-ground insulation with potentials high enough to simulate power circuit transient stresses. With every test setup, high-frequency and high-potential qualitative tests of resistance, impedance, and turn balance are made, and the results are obtained by a single scope observation. High turn-to-turn voltages are applied without excessive winding-to-ground stresses. Non-destructive testing is assured even on fractional horsepower motors and generators, and destructive fault location is possible.

Power supply for the mobile unit is 115-125 v, 60 cycle, 16 amp; 7 amp for the portable model. If the voltage supply fluctuates more than +10 or -5 percent, and automatic regulating transformer will be required.

*Westinghouse Electric Corp., Electronics & X-Ray Div., Baltimore 3, Md.*

## Cageless Bearing with Self-Aligning Rollers



The design principle of the guided roller bearing that maintains roller alignment without space-wasting cages is the use of grooved rollers and a guide rail to keep the rollers in alignment. Like a lever in balance, any shift off-center causes contact between roller and rail, and returns the roller to the true axis.

Known as the guiderol roller bearings, they have more load-carry rollers in a given diameter bearing, with a consequent increase in load carrying capacity. Because the rollers are guided, less internal looseness is needed to allow for roller correction.

The bearings may be mounted in any position from horizontal to vertical, and are available in roller bearings dimensionally interchangeable with needle-roller types, and cylindrical roller as well as ball bearings of single and double row sizes.

With each roller making effective race contact, almost to the outside edges of the races, the wide support increases axial rigidity, important in such single unit applications as gears, rollers, sheaves, and levers. The open end construction permits free circulation of the lubricant, s ting up a flushing or cleaning action inside the bear

*McGill Mfg. Co., 1100 N. LaFayette St., Valparaiso,*

A NEW POSITIVE MECHANICAL SHAFT SEAL, designed to withstand high speeds, temperatures, and pressures, may be used with almost all liquids and gases without deterioration. Because of its simple design, it can be varied for most operating and assembly conditions, while occupying a minimum of space. Cartiseal Corp., 1449 W. Randolph St., Chicago 7, Ill.

A NEW PORTABLE CALCULATOR, made by Swiss watchmakers, will add, subtract, multiply, divide, figure square roots, factors, cubes, percentages, a is as easy to operate as a slide rule. carries to five decimal places and to to 99 billion. The unit is appro mately 2 in. in dia; 3½ in. long, weighs 8 ounces. Curta Calculator 5543 S. Ashland Ave., Chicago, Ill

CONTINUED ON PAGE

VARIABLE SPEED REWI

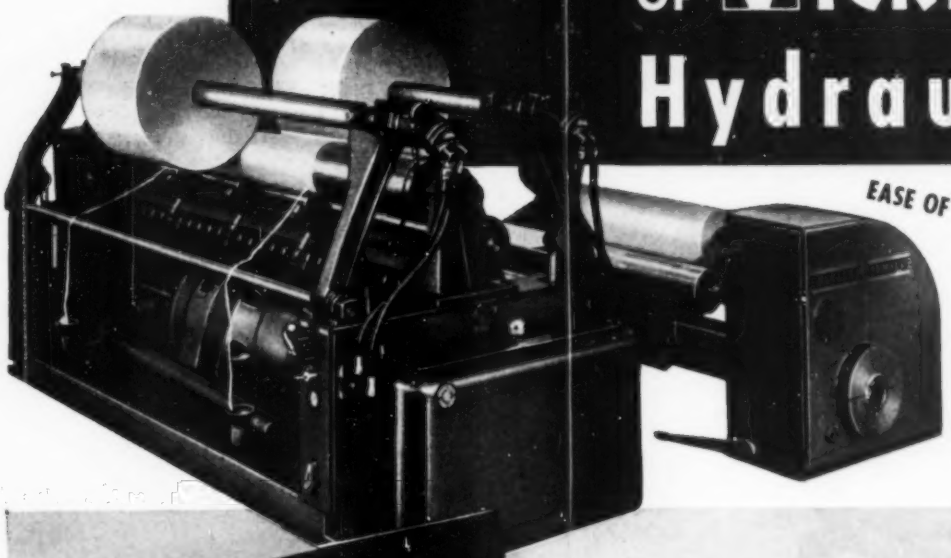
SIMPLICITY OF DE

# Another COST-CUTTING APPLICATION OF VICKERS Hydraulics

EASE OF MAINTENANCE

GREATER OUTPUT

COMPACT



## New BAGLEY & SEWALL No. 15 Duplex Slitter-Rewinder

Vickers hydraulic rewind drives contribute much to the efficient surface, differential or center winding of this fast-operating machine. No power is wasted. Maximum rewind shaft driving torque is set manually for each type of winding. Varying power demand of the rolls controls the speed of the hydraulic motors to automatically adjust the delivery of the variable delivery pump to the exact system requirement. Specially adjustable Vickers Relief Valve permits slow speed starting to avoid tear.

Other Vickers systems have improved performance and reduced costs for the majority of hydraulically-operated production machines built today. For details of the complete Vickers Industrial Machinery line, write for Catalog 5000 or contact your nearest factory trained Vickers application engineer.

**VICKERS Incorporated** • 1454 OAKMAN BLVD. • DETROIT 32, MICH.

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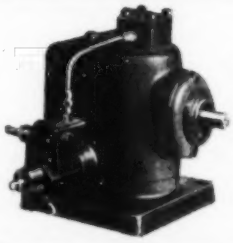
ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921



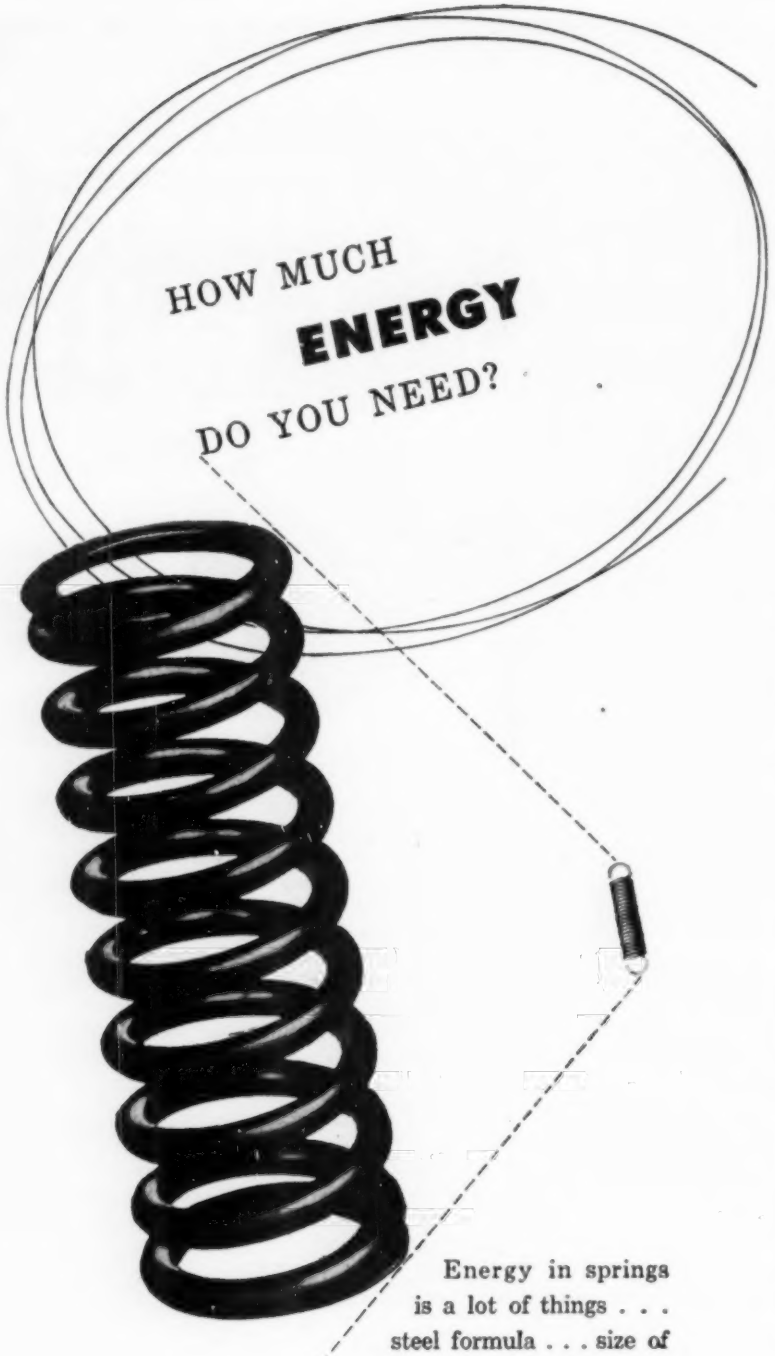
Vickers Variable Delivery Piston Type Pump with pressure compensated control—delivery is automatically regulated by signal pressure change at compensator. Capacities from 5 to 350 hp.

Vickers Constant Displacement Piston Type Hydraulic Motor. Torque is preselected by manual adjustment at the pump.

Vickers Balanced Piston Type Relief Valve

Vickers Proportional Oil Filter

476

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**AMERICAN-FORT PITT *Spring* DIVISION**

**H. K. PORTER COMPANY, INC.**

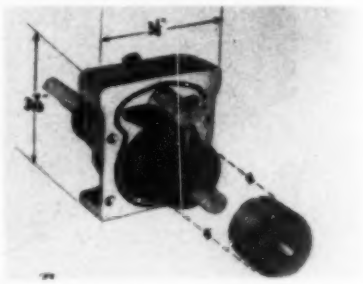
**2 John Street, McKees Rocks, Pa.** *(Pittsburgh District)*




## Chemical Process Pumps Use Teflon Impellers

Standard equipment on this new line of chemical process pumps are teflon impellers, a teflon packed stuffing box, and a choice of teflon or graphitar self-lubricating bearings. Teflon is chemically and biologically inert, and is unaffected by any acid, organic solvent, or alkali solution.

Manufactured with stainless steel pump casing and shafts, these pumps are used for small volume process or laboratory work, transfer applications, and pilot plant and industrial applications. Being positive displacement



pumps, they also find application in pharmaceutical, fine chemical and other process plants. The pumps will operate in either direction in capacities from 1 to 20 gpm, and pressures up to 40 psi with good lift. Capacities are subject to viscosity, temperature, and specific gravity.

The impellers will not swell, shrink, harden or crack. They have a low coefficient of friction, zero moisture absorption, plus good non-adhesive properties.

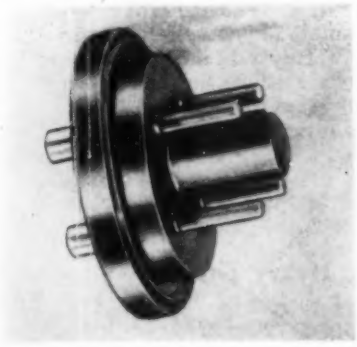
The pumps are available in port sizes of $\frac{3}{8}$, $\frac{1}{2}$, and $\frac{3}{4}$ in. pipe tap, with pulley drive base assembly, or base mounted direct connected with electric motors. Available in No. 316 stainless steel precision castings, or naval bronze forgings.

*Eco Engineering Co.*, 12 New York Ave., *Newark* 1, *N. J.*

## Nylon Plug Base For Capacitors

A new plug base, model 1800, manufactured for capacitors of the type CE50 series, and fitting a standard medium octal socket, is suitable for use in condensers made under JAN-C-62 specifications.

By using Nylon, the following advantages were possible: the toughness of the unit reduced breaking to a minimum when being assembled; its high strength permitted hollowing out of the unit, making it lighter and saving



material; the nylon used has a melting point of 425 F, and has good electrical properties.

Through the use of nylon, advantages are possible over ordinary phenolic bases. Most important is the toughness of the unit which reduces breakage to a minimum while being assembled to metal cans, or other related parts. Because of the high strength of this material it has been possible to hollow the unit to a great extent, thus making it lighter and creating a savings in material. The nylon used on this base has a melting point in excess of 425 deg F. and good electrical properties as well.

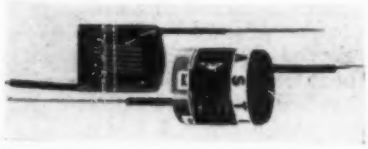
Slight resiliency of the material eliminates danger of base cutting cathode tabs, and results in a better seal to the metal can. This same resiliency reduces the chances of the can rotating on the base, either during or after the spinning process.

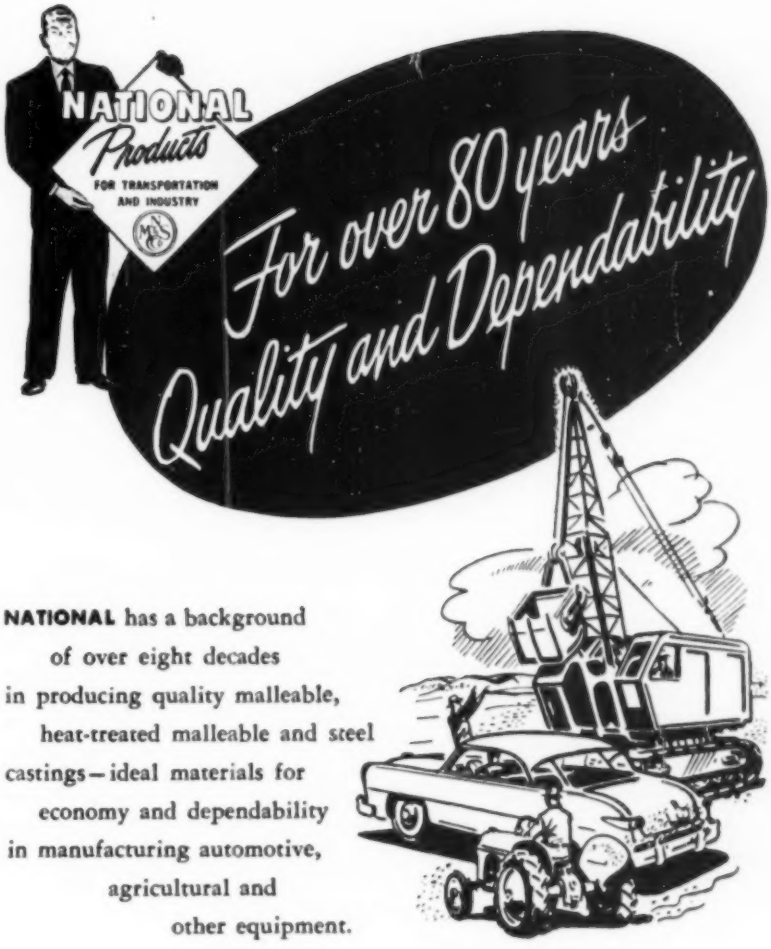
*Industrial Devices, Inc.,*
*22 State Rd., Edgewater, N. J.*

## Molded-In Electronic Selenium Rectifiers

All ratings up to 200 MA d-c output in the plastisel line of miniature electronic selenium rectifiers are molded-in, similar to small tubular condensors. The outer case is spiral-wound phenolic wax which is rock hard at 100 C. The good thermal conductivity of this wax, and the low loss plates compensate for the loss of cooling due to molding-in. These rectifiers are manufactured with bare or insulated tin-copper leads.

In ratings from 250 MA d-c to 500 MA d-c, the standard open plate construction is used. However, the high-efficiency plates give cooler operation and longer life. All open and closed

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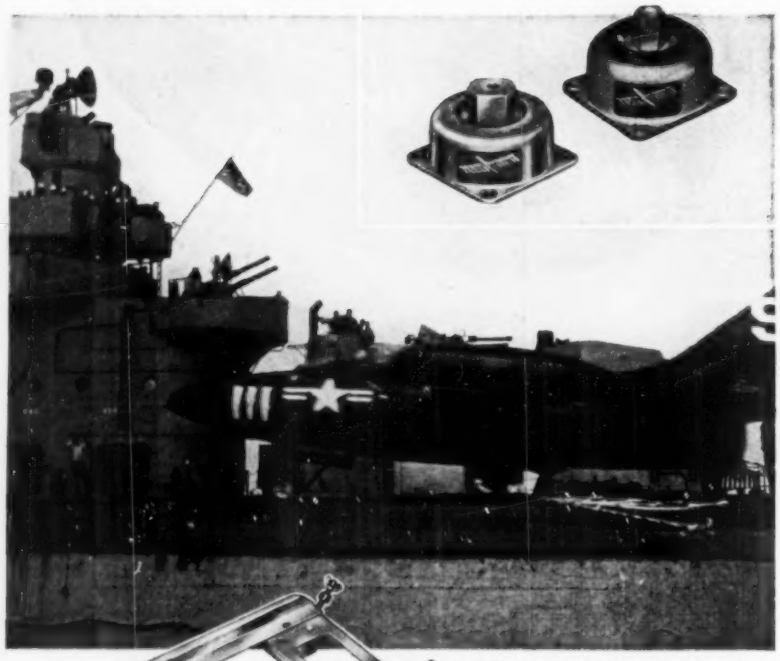

*Official United States Navy Photograph*

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Ruggedized Air-damped and All-Metl Barrymounts and mounting bases are now available to meet the shock test requirements of specifications MIL-T-5422 (Aer), MIL-E-5272 (USAF), and ANE-19. These mountings hold your equipment securely and maintain uniform performance characteristics even after the repeated shock of many aircraft carrier landings.

For full information about Barrymounts and bases, write today for your free copy of each of these Barry catalogs:

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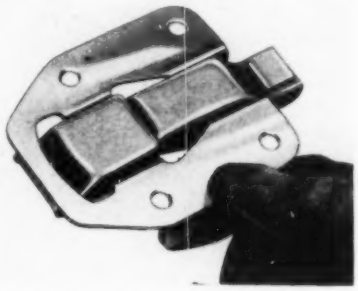
construction stacks are standard in 380 PIU ratings (130 v a-c into a condensor). They can also be had in other voltage ratings and as doubler units for special applications. All rectifiers are guaranteed for 1,000 hrs or 1 year.

*Electronic Devices Inc., Precision Rectifier Div., 429-12th St., Brooklyn, N. Y.*

## Large, Heavy Duty Flush Latch

Designed for heavy duty applications in access panels and inspection doors on heavy equipment, a new giant



flush latch contains a spring loaded button that allows for variations in closure contact and misalignment, assuring tight fit of all panels and doors.

The latch, called H-5150, is made of heavy gage stainless, coated cold rolled steel, or heat treated aluminum in many combinations of trigger and bolt offsets.

*Hartwell Co., 9035 Venice Blvd., Los Angeles 34, Calif.*

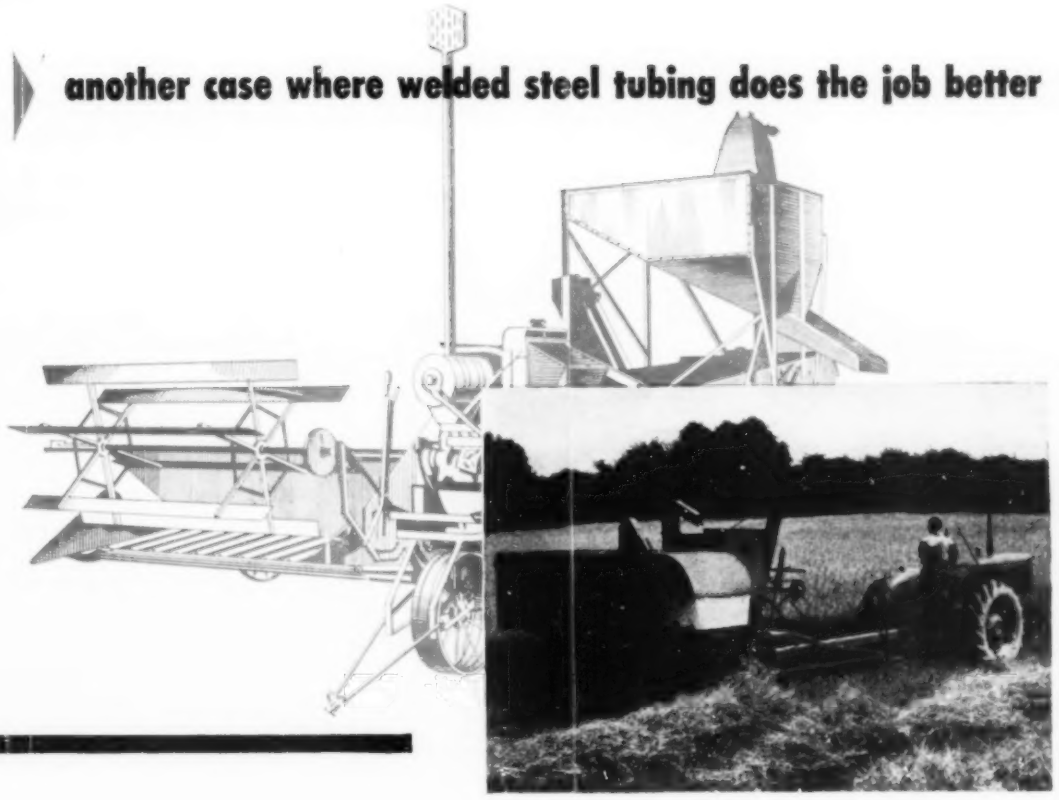
## 50 Watt, Heavy Duty, Rheostat

Because of a high temperature enamel used in its construction, a new 50 w rheostat is said to have an increased safety factor, and is shock resistant. This enamel coating gives complete protection under extremes of humidity and abnormal atmospheric conditions, and binds the toroidal ceramic form to the refractory base.

The different design of the contact arm permits the use of a buss bar type brush that gives a minimum of resistance between the resistive element and collector ring. A self-adjusting design gives positive electrical control.

Other features are: trouble free constructions, with a minimum number of parts enameled to the hub, and a contact arm tension designed to give uniform torque and adjustable brush pressure. The rheostat complies with the current standards of: military specifications JAN-R-22, R.T.M.A.,

## another case where welded steel tubing does the job better



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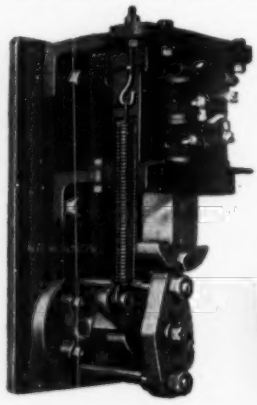

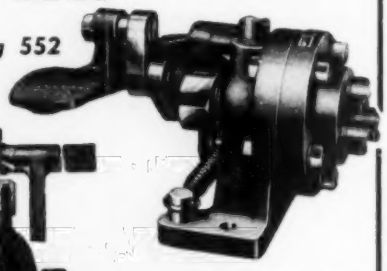

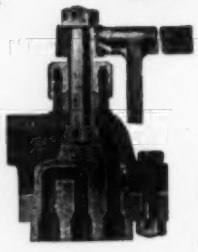

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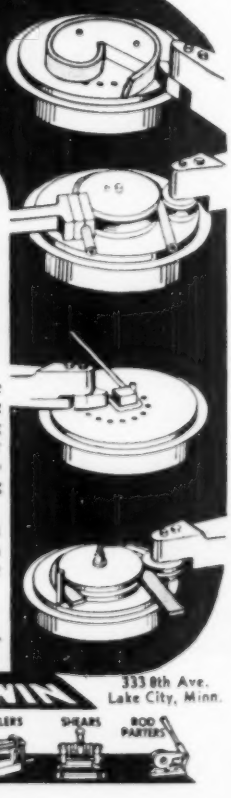

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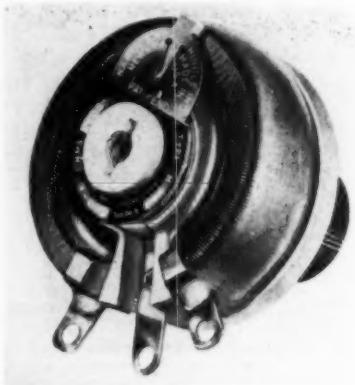

NEMA, and Underwriters' Laboratories.

Specifications: diameter of base, $2\frac{3}{8}$ in.; depth behind panel, $1\frac{7}{16}$ in.; shaft, $\frac{1}{4}$ in. dia projecting; shaft rotation, 305 deg ±5. Maximum amperage for 0.50 ohms is 10 amp; for 10,000 ohms it is 0.70 amperes.

*Hardwick, Hindle Inc., Newark 5, N. J.*

## Clamp Anchors Cable At Terminal Points

To meet the requirements for a fitting suitable for a bus drop cable, a new quarter bend cable clamp known as the sky-tie has been developed for suspending the cables above the machines. This method simplifies the means of transmitting power to the machines from the bus duct, and makes for easy arrangement of the machines.

Two identical pieces form the device, joined by two heavy bolts, and installation consists of tightening these bolts with the support in position.

A spring is also necessary and is used to keep the cables tight. This spring fits onto the sky-tie in the hole located at the bend, ties back to a structural member, and absorbs vibration or shocks to the installation.

The spring can be used on loads as high as 125 pounds. The manufacturers claim that the weight of the cable does not necessarily determine the spring requirement. This is deter-

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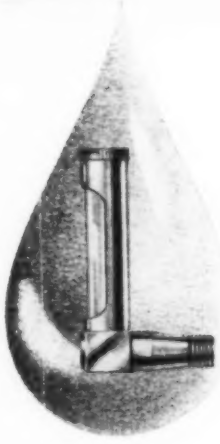

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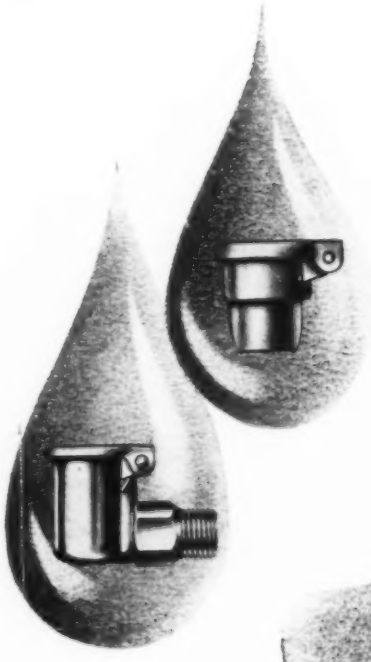

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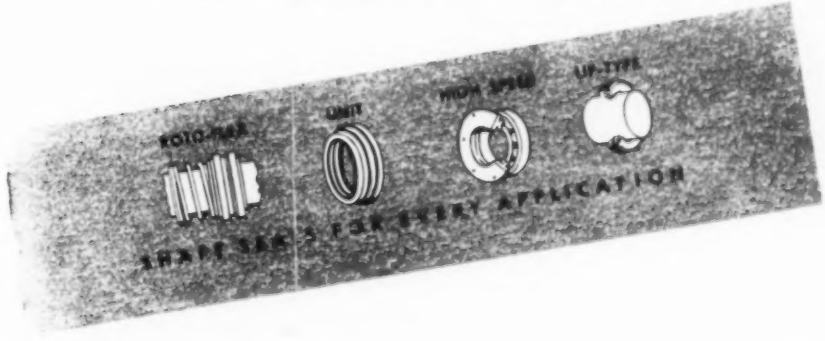

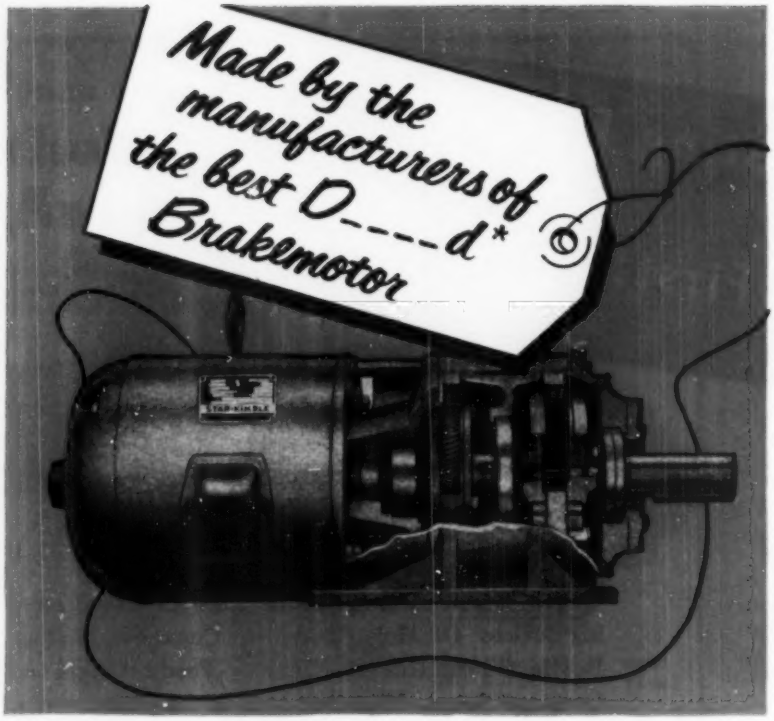


# PLANETARY DRIVE REDUCES WEAR... LENGTHENS LIFE of Star-Kimble Gearmotors

THE planetary gear speed-reducing system used and proved for a quarter of a century in Star-Kimble Gearmotors distributes the bearing load uniformly and reduces the risk of wear.

Helical gears of the planetary system are precision-shaved in Star-Kimble's own plants for the continuous tooth contact that assures quiet operation and long life.

Moving parts within the sturdy reducer housing maintain a constant fine spray of lubricant from an oil reservoir to the bearings and gears. Oil seals prevent leakage.

Tapered roller bearings on output shaft eliminate end play—allow Gearmotor to be mounted in any position.

*Most important advantage of all* is the fact that every Star-Kimble Gearmotor is an integrally designed, integrally built unit. All parts are Star-Kimble engineered to work smoothly and efficiently together—all motors, gears and other major components are produced by Star-Kimble.

*Demanded by industry for tough start-and-stop jobs.

**For the facts on Star-Kimble Gearmotors, write for a copy of Bulletin B-601.**

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**211 Bloomfield Avenue Bloomfield, New Jersey**



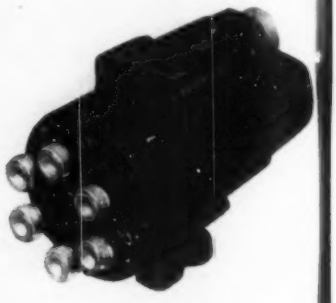

mined by the pull needed to keep the horizontal run of cable from sagging, and in some cases 75 to 100 lb is exerted by cable whose weight may be only 15 pounds.

The approximate length is 5 inches. The two sizes available are from $\frac{3}{8}$ to $\frac{1}{2}$ in., and from $\frac{3}{4}$ to $1\frac{1}{8}$ inches.

*The Adalet Mfg. Co.*, 14300 *Lorain Ave., Cleveland 11, Ohio*

## Motor-Operated Coaxial RF Switch

A new, compact, double pole double throw coaxial RF switch has been developed to replace the use of two single pole double throw switches and to cause a saving in weight and flexibility of installation. The new switch is motor-operated instead of solenoid. Straight end connectors



eliminate use of angle connectors, and save time and space. Frequency range is up to 11,000 mc/sec, VSWR is less than 1.3 to 1, insertion loss is less than 0.5 db throughout operating range. Attenuation between unused connectors averages 55 db. Other models are available for aircraft applications involving extreme temperature and shock conditions.

*Transco Products Inc.*, 12210 *Nebraska Ave., Los Angeles 25, Calif.*

## Easy Operating Tube Bender

A new combination tube bender that bends both $\frac{1}{2}$ in. and $\frac{5}{8}$ in. O.D. copper, aluminum, brass, and other soft, thin wall metal tubing, has a dual size shoe and mandrel which permits bending two different sizes of tubing without changing any parts.

The bender is of two piece construction, and comes apart and slips over the tube at the point where the bend is needed. Therefore, it can be used to bend tubing where one end is connected, as easily as it can be used to bend tubing that has both ends free. The two-piece construction also makes it easy to remove the bender from the

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Plus Fabricating of our own tubing Michigan is interested ONLY IN THE FABRICATION OF Stainless steel, copper, brass and aluminum tubing.

Vacuum Cleaner Handle

An excellent example of how the use of welded steel tubing simplifies assembly of parts, cuts down costs, is the cleaner handle made by Michigan for manufacturers of vacuum cleaners.

The handle is shipped by Michigan ready for chrome finishing and assembly to the vacuum cleaner. Stampings for the cord holders are welded to the tubing, an elongated hole punched for the interior wire cord and tumbler switch. The surface finish of the cold rolled steel tubing, as processed by Michigan, is suitable for polishing and chrome plating.

No matter what you manufacture, Michigan engineers will be pleased to consult with you concerning an application of welded steel tubing to improve your product and lower production costs.

Consult us for engineering and technical help in the selection of tubing best suited to your needs.

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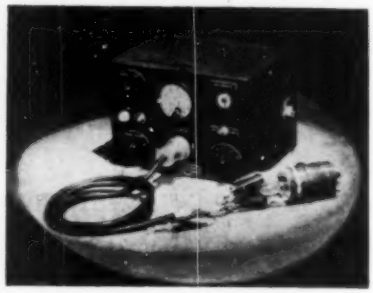
ing after the bend is completed. The bender does not mar, or deform the tubing.

Bends can be made to any angle up to 180 deg and the bender is calibrated to show the degree positions. The overall length is 21 in. and weight is 3 pounds. The bender is of steel and aluminum construction.

*The Imperial Brass Mfg. Co., 1200 W. Harrison St., Chicago 7, Ill.*

## New Synchro Zeroing Device

A new instrument, the Synchronull model U100, designed for zeroing synchros of all types, features adaptability to both 60 cps and 400 cps synchros of all types and sizes. An easy switching operation automatically selects proper test-circuit connections for



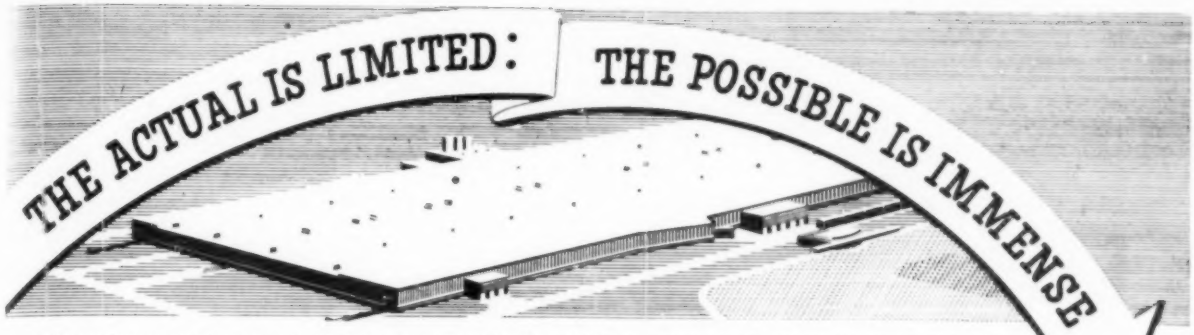
each type of synchro, as well as the proper sequence of test circuits for the zeroing operation. This procedure eliminates the possibility of making improper connections, eliminating errors in test results, and assuring safety of personnel and equipment. High sensitivity in the null-indicating tuning eye permits high zeroing accuracy. Ten millivolts, corresponding to about 0.6 min. of angular error, can be clearly detected.

*Ultrasonic Corp., 61 Rogers St. Cambridge, Mass.*

## Small, Combination Starter And Circuit Breaker

A combination across-the-line motor starter with circuit breaker, in which the components are mounted "side-by-side", has been developed for use where such a mounting is necessary for reasons of space and arrangement. This starter has the same self-indicating slamproof handle as the standard design with vertical-mounting. The handle has separate positions for: on, tripped, off, reset, and open cover.

This starter is available in sizes 0, 1 and 2 in sheet-steel enclosures for NEMA types 1, 1 A, and V. Modifica-




NEW LINCOLN PLANT CREATED BY INCENTIVE-INSPIRED CO-ACTION IN DEVELOPING POSSIBILITIES IN PRODUCT

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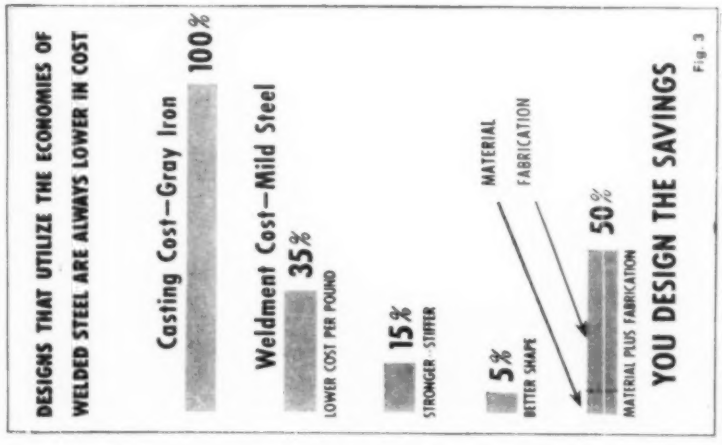
Whenever weldment costs do not approximate this yardstick, designs generally are falling short of incorporating the full economies of welded steel. A Lincoln Welding Engineer will gladly demonstrate how you can benefit on present and future product developments. Call or write.




## PROPER DESIGN IN WELDED STEEL ALWAYS IMPROVES PRODUCT AND LOWERS COST

**Fig. 1—Original Construction** *of hanger. Cost....$5.20. Weight 18 pounds.*

**Fig. 2—Present Weldesign in Steel**
*Saves 52% in cost. Costs....$2.50 Weighs 12 pounds.*

*Photos courtesy Dorsey Trailer Company, Elba, Alabama.*

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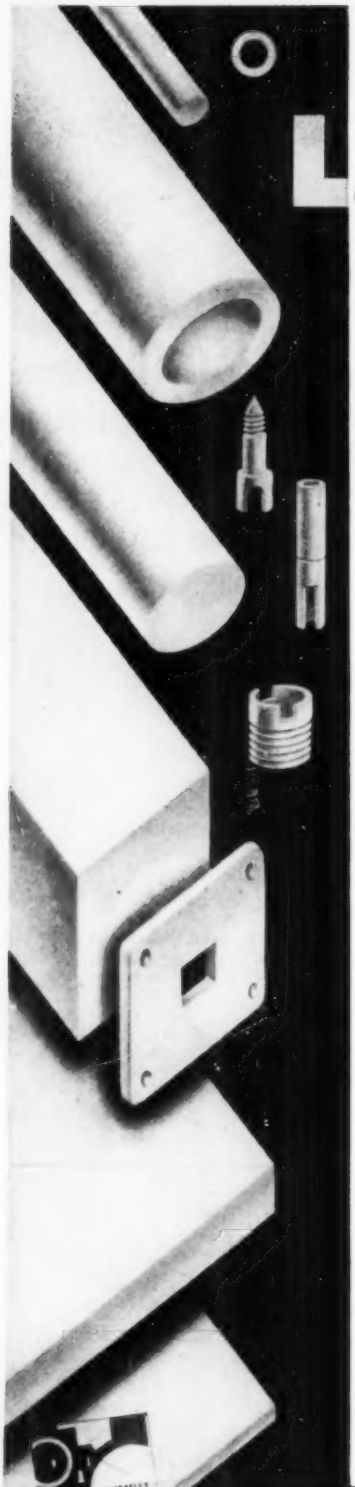

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Produced in *uniform* diameters, Fluoroflex-T rods feed properly in automatic screw machines without the costly time and material waste of centerless grinding. Tubes are concentric — permitting easier boring and reaming. Parts are free from internal strain, cracks, or porosity. This means fewer rejects, longer service life.

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## Quick Connecting Hooks

Quick-connector hooks, a simple, fast method for attaching lines to other lines, wire rope, rope or chain or to fixed objects, can be joined by a turn of the fingers, or in the dark

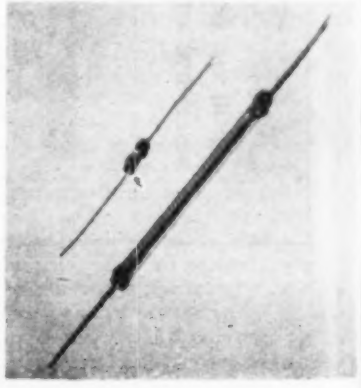
by "feel" alone. Once joined they cannot come apart unless intentionally disconnected. The hooks are made in several sizes of manganese bronze and in lightweight units made of tern alloy.

*Brummel Hook Co., Chicago 40, Ill.*

## Miniature Selenium Rectifiers

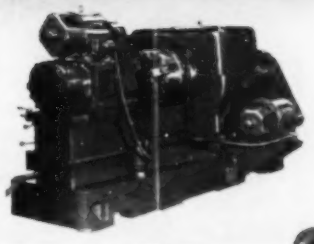
Known as the microstak line, these miniature, hermetically sealed selenium rectifiers with cell sizes as small as 0.060 in. dia. are available in a wide range of current and voltage ratings. The hermetic seal is made by metallized glass to metal bond which is said to give stable operation in high humidity, dust, corrosive fumes, and changing pressures.

The units have been used in digital

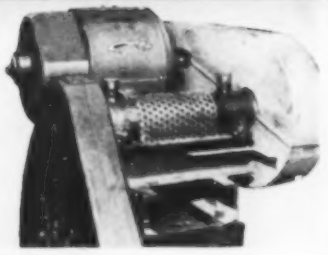


1. Two adjustable speed D.C. Motors used on a special lathe.

2. A wide speed range adjustable speed D.C. Motor used on a tire building machine.



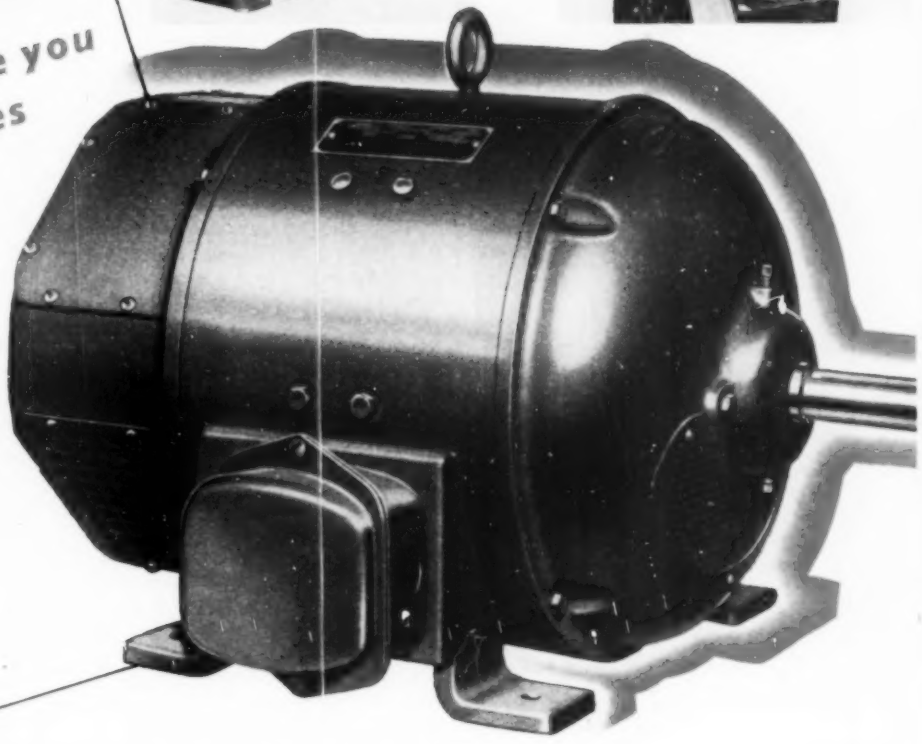
1



2

## .C. Motors give you hese advantages

- Adjustable speeds
- High starting torques
- Smooth, fast acceleration of high inertia loads
- Small change in speed with change in load
- Fast stops, with dynamic braking
- Ample maximum torque for wide variations in load



# *and* LOUIS ALLIS D. C. Motors give you a size and type for every industrial requirement

When you need flexibility you can't get from A.C. — when you need refinements of operation, to get rapid, accurate response — that's when experienced design men turn to Louis Allis D.C. Motors.

You can get standard Louis Allis D.C. Motors in sizes up to 200 HP and speeds up to 3500 RPM. They are furnished with shunt, series, or compound windings — for all standard and special voltages — with continuous or intermittent duty ratings.

Both special and standard sizes and types are available, with various electrical and mechanical characteristics — open, drip-proof, fully enclosed, splash-proof and explosion-proof enclosures can be supplied.

Louis Allis D.C. Motors are extensively used to drive hoists, machine tools, pumps, elevators, centrifugal casting machines, extractors, printing presses, stokers, conveyors and other equipment.

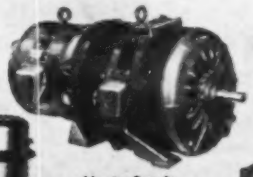
For the best solution, discuss *your* drive problems with the Louis Allis Engineer nearest you.

**THE LOUIS ALLIS CO., *Milwaukee 7, Wisconsin***

DC-101

**We specialize in SPECIAL MOTORS**

Extractor Motor with Integral Blower



Special Arbor Type Motor

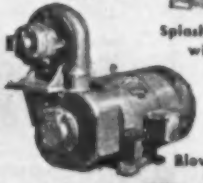
Splash-Pro with Fl

Self-Cleaning Textile Motor

Gearmotor

Single Phase Pump Motor with Tripod Base

Sanitary Motor



Blower V Freq Con

Rolled Shell Shuttless Motor

Oil-Well Pumping Motor

**Standard or special — we build it. Whatever electrical or mechanical modifications or features you need, there is a Louis Allis motor that will do your toughest jobs better.**

**30 DAY DELIVERY**

**O-M CYLINDERS**
**AIR HYDRAULIC WATER**

MORE POWER In less space
At **LESS COST**

O-M is *All* Cylinder—packing more *power* per square inch than any other type! No tie rods or bulky end caps, saves ⅓ in installation space. In full range of sizes from 1½" to 8" bores. All machined steel with bearing bronze. Parts and mounting brackets fully interchangeable. Special design standard parts applicable to almost all "custom" installations.

ORTMAN MILLER MACHINE CO.
Hammond, Indiana

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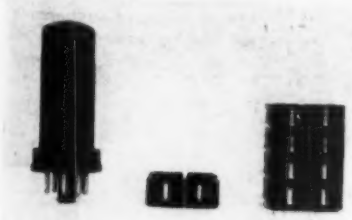
and analog computers, hearing aids, airborne radar, CRT bias supplies, and other electronic circuits.

Shown in the illustration are the 36 v to 4500 v peak inverse rating. Actual length of the 4500 v unit is 2¾ in. long by ⅜ in. diameter.

*International Resistance Co., 401 N. Broad St., Philadelphia 8, Pa.*

## Device Counts Impulses To any Desired Ratio

The perma-memory multiple scaler is a counting device that counts down incoming pulses to any desired ratio, whether the pulses are repetitive or random. It needs only one triode per binary stage. The count accumulated is stored permanently in a magnetic

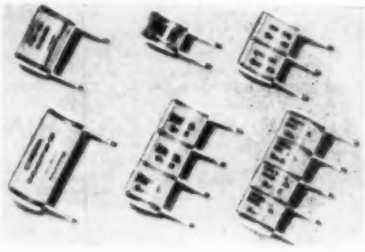


memory with the triode acting only for triggering action. In the illustration, the center unit is a binary scaler, and the stack at right is a decade scaler.

*Wang Labs., 296 Columbus Ave., Boston 16, Mass.*

## Miniature, Lug Type Resistors

To a resistor line has been added an entire series of BW resistors. The new series has soldered lugs in all sizes which range from single section chapron-wound to a 4-section resistor

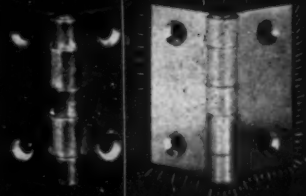


and multi-pi winding in the larger type.

Wattage ratings are of ¼ to 1 w, and resistance values from 1 ohm to 1 megohm. Available in 4 alloys of resistance wire. Resistor bobbins are of non-hydroscopic ceramics.

*Cinema Engineering Co., 1510 W. Verdugo Ave., Burbank, Calif.*


**Chrome-like Brilliance on Zinc**




**LUSTER-ON®**
**makes the difference**

At less than 1/5¢ per square foot you can have brilliant finishes like this with Luster-on Utility bright dip for zinc. It's easy to apply and control and there's plenty available — no shortages. Every day former users of nickel and cadmium are converting to this passivating bright dip.

**CHECK LIST**

Do you produce parts like those listed below? Then you can obtain corrosion-resistant, brilliant finishes at lowest costs with Luster-on Utility 15 or 25.

- Cabinet Hardware
- Small Tools (wrenches, etc.)
- Auto Body Parts
- Bathroom Hardware
- Aircraft Metal Parts
- Wire Goods
- Refrigerator Shelves
- Radio Speakers, Chassis, Shields
- Television Parts
- Electrical Parts
- Air Conditioning Fans, Guards, etc.
- Bolts, Nuts, Washers, etc.
- Builders' Hardware
- Outdoor Metal Articles (fences, trailers, etc.)

**Also**

**Protective Finishes**
**Khaki Drab Luster-on**

With 300 hours of salt spray resistance Luster-on Khaki Drab far exceeds U. S. Government Specifications of 96 to 100 hours. This chromate type conversion coating has been developed primarily for electro-deposited zinc plate. It is also ideal as a paint bonding treatment for later organic finishes.

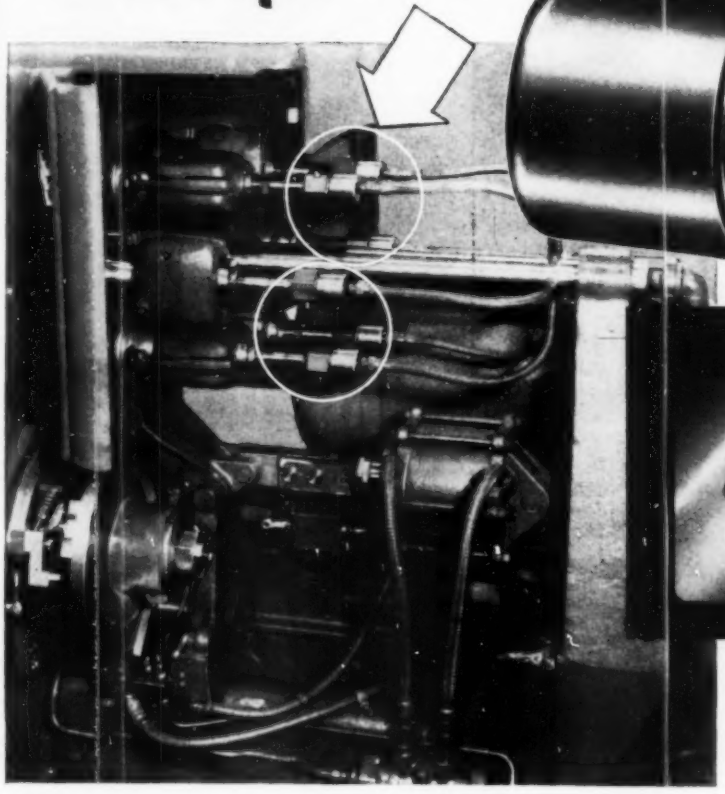
**SEND SAMPLES**

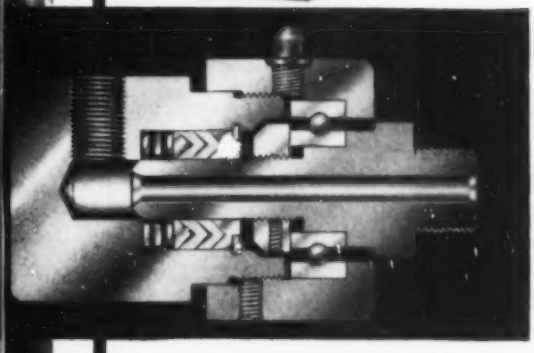
Send us samples of your parts. Let us zinc-plate and LUSTER-ON treat them for you — at No Charge. This will show you how you can dress up and protect your product simply and inexpensively with Luster-on.

THE *Chemical* CORPORATION
59 Waltham Ave., Springfield 9, Mass.

# Low Torque! Leakproof!

BARCO





## TYPE V REVOLVING JOINTS

- **LIGHT RUNNING!** Ball bearing design handles both radial and light end thrust with low torque and minimum wear.
- **LEAKPROOF!** Thanks to Barco's *exclusive* "CTR" V-ring type seal.
- **PRECISION-BUILT!** All parts machined to close tolerances. Parts interchangeable and renewable.
- **COMPACT, DURABLE!** Easy to install where space is limited. Withstands rugged service.
- **WIDE SPEED RANGE!** Up to 2500 RPM on light pressure applications. Lower speeds for high temperatures and pressures.

*For High Speed Rotating Connections to*

**SPINDLES • CHUCKS • CLUTCHES**

When you need *high speed, low torque, leakproof* rotary connections for fluid lines on MACHINE TOOLS, use Barco TYPE V Revolving Joints! The above photograph shows a typical installation on a new 6-spindle "Automatic" produced by Greenlee Bros. & Co., Rockford, Ill. This is but one of the many applications in the machine tool industry for TYPE V joints. Barco builds a complete line of standard and special revolving joints to meet virtually every need. *Barco Engineers are at your service; ask for recommendations.*

**BARCO MANUFACTURING COMPANY**

**1827F Winnemac Avenue, Chicago 40, Illinois**
***In Canada:* The Holden Co., Ltd.**
*The Only Truly Complete Line of Flexible Ball, Swivel, Swing and Revolving Joints*

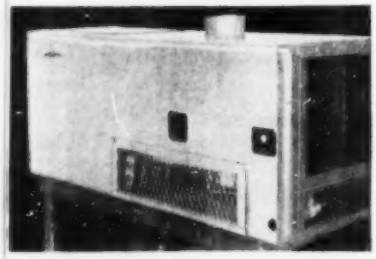
# Sicon*

**HEAT-RESISTANT FINISH**

**A PRODUCT OF THE SILICONES*

**1. Sicon Protects Gas Heater Combustion Chambers at 875°**

**2. Sicon in COLORS Preserves Appearance of Heating Equipment Indefinitely**



CENTRAL GAS HEATER
Mfg'd by the JOHN ZINK CO., TULSA

For years the protection of combustion chambers and outer coverings of heating equipment has been a problem.

The John Zink Company, a leading manufacturer of gas heaters, solved this problem with SICON.

SICON protects their combustion chambers against extreme high heats of 875° without powdering or losing its color.

SICON, in attractive colors, also preserves the outside appearance of their products, adding greatly to sales appeal, and prolonging life.

The John Zink Company now uses SICON for all hot applications.

Inside and outside—SICON is the finish that can often do the job where all others fail.

**WRITE FOR LATEST TECHNICAL DATA TODAY**

Sicon

*Silicone-Base Finish is manufactured exclusively by*

MIDLAND INDUSTRIAL FINISHES CO.

Waukegan, Illinois

ENAMELS · SYNTHETICS
LACQUERS · VARNISHES


# MEETINGS

May 12-14

INSTITUTE OF RADIO ENGINEERS—National Conference on Airborne Electronics, Dayton Biltmore Hotel, Dayton, Ohio.

May 14-16

SOCIETY FOR EXPERIMENTAL STRESS ANALYSIS—Spring Meeting. Hotel Lincoln, Indianapolis, Ind.

May 17-June 2

PARIS INTERNATIONAL TRADE FAIR—1952 Exposition, Port of Versailles, France.

May 22-24

AMERICAN SOCIETY FOR QUALITY CONTROL—Annual Convention, Onondaga County War Memorial Auditorium, Syracuse, N. Y.

June 1-4

AMERICAN GEAR MANUFACTURERS ASSOCIATION—Annual Meeting. The Homestead, Hot Springs, Va.

June 1-6

SOCIETY OF AUTOMOTIVE ENGINEERS—Summer Meeting, Ambassador and Ritz-Carlton Hotels, Atlantic City, N. J.

June 2-13

CANADIAN INTERNATIONAL TRADE FAIR—Toronto, Canada.

June 4-10

INTERNATIONAL MECHANICAL ENGINEERING CONGRESS — Stockholm, Sweden.

June 4-14

MECHANICAL HANDLING EXHIBITION AND CONVENTION — Olympia, London, England.

June 15-19

AMERICAN SOCIETY OF MECHANICAL ENGINEERS—Semi-Annual Meeting, Sheraton-Gibson Hotel, Cincinnati, Ohio.

June 16-20

INDUSTRIAL FINISHING EXPOSITION—Sponsored by American Electroplaters Society. International Amphitheatre, Chicago, Ill.

June 19-21

AMERICAN SOCIETY OF MECHANICAL ENGINEERS—Applied Mechanics Division, Symposium on Shock and Vibration Instrumentation. Pennsylvania State College, Penna.


WORKS WHERE OTHERS WON'T

*accurately formed*

**GRAPHALLOY OILLESS BEARINGS**

SPECIFY GRAPHALLOY WITH CONFIDENCE

TRADE MARK REG. U. S. PAT. OFF.

**SELF-LUBRICATING ● EXTREMELY DURABLE ● CONSTANT CO-EFFICIENT OF FRICTION ● OPERATES DRY — OR *SUBMERGED IN WATER, GASOLINE OR CORROSIVE LIQUIDS* ● APPLICABLE OVER A WIDE TEMPERATURE RANGE — *even where oil solidifies or carbonizes* ● EXCELLENT AS A CURRENT-CARRYING BEARING.**

GRAPHITE METALLIZING CORPORATION

1012 NEPPERHAN AVENUE, YONKERS 3, NEW YORK

# They found new ways to KEEP COSTS DOWN

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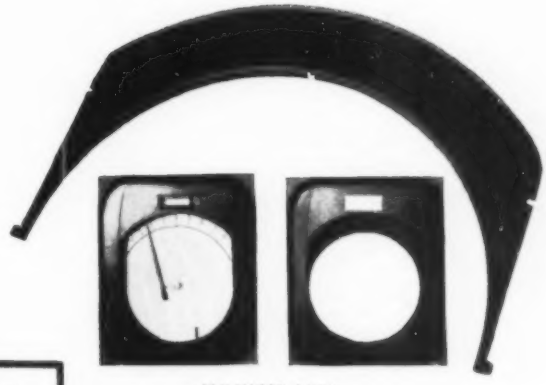
Popex Inc.



FLO METER DOOR
Penn Industrial Instrument Corp.

ONE-PIECE CASE
L. C. Smith and Corona Typewriters, Inc.

COLOR SLIDE VIEWER
The FR Corporation

## ...with custom-molded DUREZ phenolics

From all directions the news rolls in from Durez phenolics users . . . and it's *good* because it's news of costs saved in product development, improvement, and redesign . . .

*Formerly 19 assembly operations . . . now six.*

*Inexpensive insert makes "new" model. Tool and jig requirements slashed. Finishing eliminated.*

Reports like these point up a thought to have in mind when *your* products are in the making . . . it pays to talk things over with your custom molder. He has the know-how that translates new ideas into r Aded Durez. His equipment is large enough for big moldings and is getting larger all the time.

Of course the plastic must have good flow and strength properties to permit wide freedom in design for molding. Durez has both . . . and it offers your engineers eight distinct classes of phenolics among which they can select the mechanical, electrical, and chemical properties that fit their specifications.

Our technicians can aid you with specialized knowledge of these materials and their use. Call them any time.

*Our monthly "Durez Plastics News" will keep you informed on industry's uses of Durez. Write, on office letterhead, to Durez Plastics & Chemicals, Inc., 2005 Walck Road, North Tonawanda, N. Y.*

**PHENOLIC PLASTICS THAT FIT THE JOB**

THIS handsome indoor-outdoor "Twin-Temp" Thermometer, product of Seegers Manufacturing Company, tells at a glance the comparative temperature in your home and outside. Chace Thermostatic Bimetal is the actuating element for the upper "indoor" dial. A gas-filled bulb connected by a capillary tube to linkage behind the "outdoor" dial performs a similar function from a remote location on your window frame.

The thermostatic bimetal element is a precision-wound coil, the outer end of which is fixed to the mounting on the back of the dial. The shaft which carries the indicator is attached to the inner end of the coil. Changes in room temperature cause the element to react in a coiling or uncoiling motion, thus rotating the indicator to the correct temperature reading.

The accuracy of this simple type of thermometer is dependent upon precision manufacturing and assembly methods. Chace furnishes this element in finished coils fabricated from precision-rolled strip, coiled in a controlled-temperature department. We also provide our 29 types of thermostatic bimetal in elements to customer designs, in strips, random coiled lengths or welded or brazed sub-assemblies. Before you proceed with the design of an element for your new temperature actuated device, consult our Applications Engineers. For a complete reference on the design and selection of bimetal elements, write for our 64-page manual.

W. M. CHACE CO.
Thermostatic Bimetal
1607 BEARD AVE., DETROIT 9, MICH.

# ENGINEERING ABSTRACTS

## Leaner Alloys for High Temperature Use

Abstracted from "Lower Alloys Developed for High Temperature Use" by C. L. Clark, Timken Roller Bearing Co., The Iron Age, February, 1952.

TO REDUCE THE DRAIN that regular high temperature alloys (many with less than 50 percent Fe) have placed on our supply of presently critical alloying elements, a series of low alloy steels have been under study in this country and in England.

A steel designated as Timken 17-22A(S), was developed several years ago for high temperature bolting applications. The mean analysis of this grade is: 0.30 C, 0.80 Mn, 0.70 Si, 1.25 Cr, 0.50 Mo, and 0.25 V. The effects of both temperature and hardness variations (heat treatment) on the rupture strength are shown in Fig. 1. When heat treated, by normalizing and tempering, to about 300 Bhn this steel has outstanding rupture strength at 1,000 F, the stress for rupture in 100 hr being of the order of 60,000 psi.

That heat treatment has an effect on the high temperature strength is shown in Fig. 1 which portrays the effect of variations in hardness on the rupture strength of 17-22A(S) at 1,000 F. In this case, the variations in hardness were obtained by tempering the material originally normalized at 1,725 F, at various tempering temperatures. However, the rupture strength of 17-22A(S) decreases above 1,000 F, to a value of 20,000 psi at 1,100 F for a fracture time of 1,000 hr.

In the attempt to meet higher properties several heats incorporating modifications in the analysis of 17-22A(S) were melted in a 300 lb induction furnace and rolled into 1 in. dia bars. These steels were then subjected to 1,100 F rupture tests in various conditions of heat treatment. The analyses, heat treatments, hardnesses and 1,000 hr rupture strength values were tabulated. The estimated elongation to fracture in 1,000 hr was also included in these comparative tests.

When all factors were considered, Heat A80, designated as Timken 17-22V, appeared to be the best of the low-alloyed steels. Its 1,000 hr rupture strength at 1,100 F is about 35,000 psi and it differs from the standard 17-22A(S) analysis only in

# Stronger!

That's the unique new SPIN-LOCK Screw.

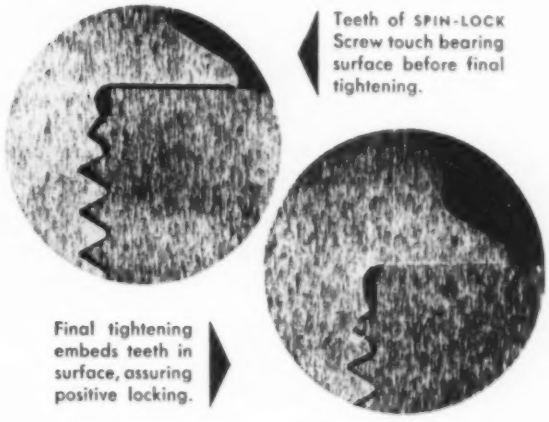
Units assembled with SPIN-LOCK are stronger because:

1. SPIN-LOCK can exert *greater clamping force* because it's heat-treated.

2. SPIN-LOCK *prevents loosening* because it locks into the surface with ratchet-like teeth closely spaced under the head's outer edge.

SPIN-LOCK has many other advantages, too. No extra parts to add...just one part to buy and stock. No special-handling...you can hopper-feed it. No projections to catch fingers or clothes. What's more, SPIN-LOCK is neater (fastens flush) ...easy to drive in hard-to-reach spots...excellent for electrical contact.

Hex, pan, truss, flat heads. Write to us or any of the companies below for complete data on types and specifications.


Teeth of SPIN-LOCK Screw touch bearing surface before final tightening.
Final tightening embeds teeth in surface, assuring positive locking.

## Spin-lock

U. S. Pat. No. 2,253,241

**The Tighter, Stronger, Surer Fastener!**

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Div. of Buffalo-Eclipse Corp.
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Rockford, Ill.

National Lock Company
Rockford, Ill.

Central Screw Co.
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Keene, N. H.

Continental Screw Company
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Great Lakes Screw Corp.
Chicago 27, Ill.

The Lamson & Sessions Co.
Cleveland 2, Ohio
Birmingham 1, Ala.
Chicago 4, Ill.

Seabcard Screw Corp.
West Warwick, R. I.

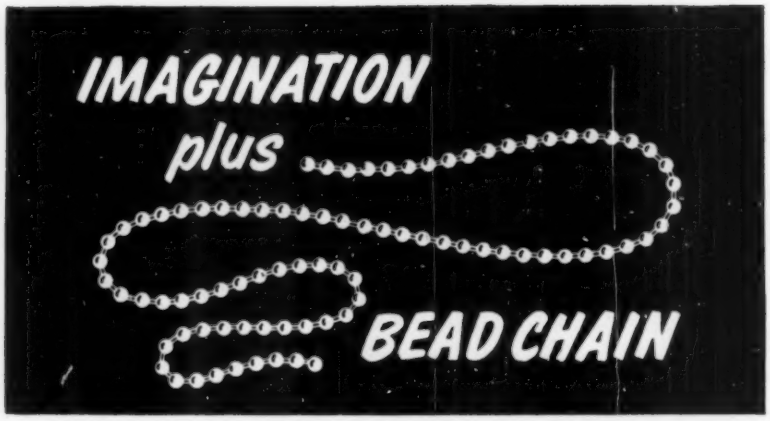
Scovill Manufacturing Co.
Waterville Division
Waterville 48, Conn.

**CANADA**

P. L. Robertson Mfg. Co., Ltd.
Milton, Ontario, CANADA

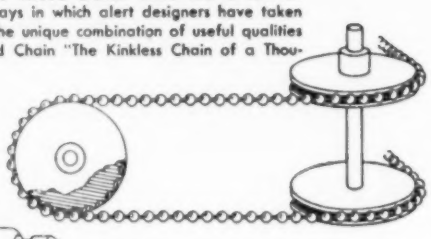
The Steel Company of Canada, Ltd.
Hamilton, Ontario, CANADA

The Stowell Screw Co., Ltd.
Longueuil, Quebec, CANADA



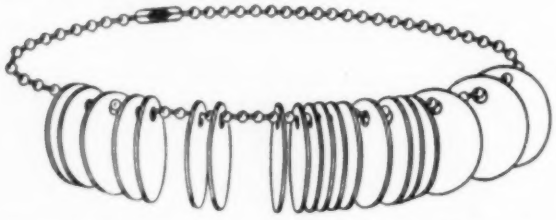

means BETTER PRODUCTS

**WHAT OTHERS HAVE DONE:** Here are a few of the scores of ways in which alert designers have taken advantage of the unique combination of useful qualities that make Bead Chain "The Kinkless Chain of a Thousand Uses".



**LOW-COST, THREE DIMENSIONAL SPROCKET DRIVE** Made possible by non-kinking, free-swiveling action of each bead. Slippage is absolutely prevented as each bead fits into an individual pocket. Bead Chain drives have been proved on many products such as business machines, television tuners, venetian blinds, etc.

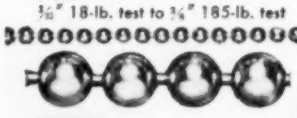
**RETAINER FOR STRAYING PARTS** Saves time at plant or at home by keeping straying parts at hand. Adds value and sales appeal for pennies.

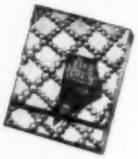


**CONNECTOR FOR SAMPLES** For fabrics, paint, plastics, etc. Convenient, non-kinking, attractive, strong.

It will pay you to think how Bead Chain could help improve your product. As the world's largest manufacturer of Bead Chain, we offer the "know-how" acquired in applying Bead Chain to meet the requirements of thousands of uses. Call on us.

Bead Chain is available in many metals and finishes, and in five sizes, from:
⅛" 18-lb. test to ¾" 185-lb. test





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The Bead Chain Manufacturing Co.,
92 Mt. Grove Street, Bridgeport, Connecticut.



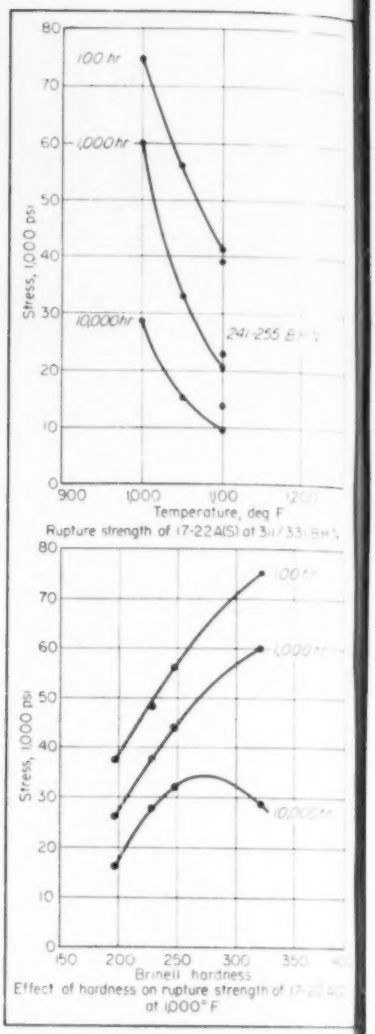
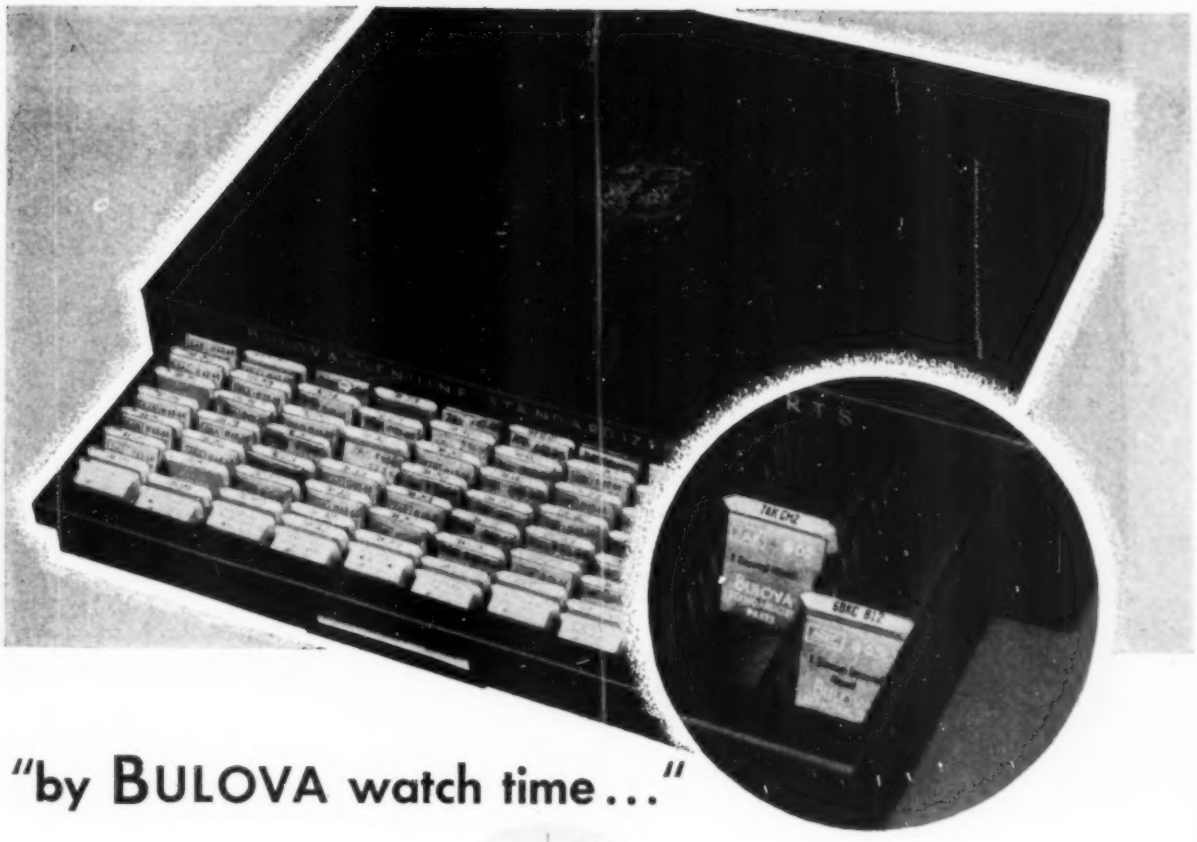




**FIG. 1—Stress-rupture characteristics of Timken alloy 17-22A(S), a low alloy steel for 1100 Fahrenheit service.**

that it contains 0.20 pct rather than 0.30 pct C, and 0.80 pct rather than 0.25 pct V. It can be readily hot worked at temperatures up to at least 2,250 F and the best rupture strength is developed by a simple heat treatment consisting of normalizing from 1,800 F followed by tempering to 300/350 Brinell. Elongation to fracture for 17-22V in 1,000 hr at 1,100 F, is about 5.0 pct, which is believed ample for the intended applications. As the normalizing temperature was increased to 1,950-2,100 F, the strength remained constant, or decreased, but the steels became very brittle at 1,100 F, showing elongations to fracture of 1.0 pct, or less. Fig. 2.

In order to determine the effect of size melt as well as section size of the heat treated part, a one ton electric



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## ...for precision packaging

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Koppers Polystyrene 81 proved the ideal choice for this new cabinet for several reasons. It offers practical, time-saving advantages and maximum convenience in use. The dividers (also made of Koppers Polystyrene) are easily moved to accommodate changing volumes of stock, and are molded of ivory-colored Polystyrene to make identifying lettering extremely readable and provide quick identification. The handsome mahogany color of the cabinet will always be fresh and new-looking.

Of prime importance is the fact that this new cabinet represents a substantial saving in manufacture and use over a previous metal model which it replaces.

Koppers Polystyrene 81 is a lubricated plastic, well suited for precision molding of this type. Its ease of flow assures that it will fill the mold, giving sharp definition to divider slots and corners, and permitting the molding of thin wall sections. Its improved physical properties plus greater dimensional stability provide a strong, rigid, good-looking cabinet and drawer that fit together perfectly.

• • •

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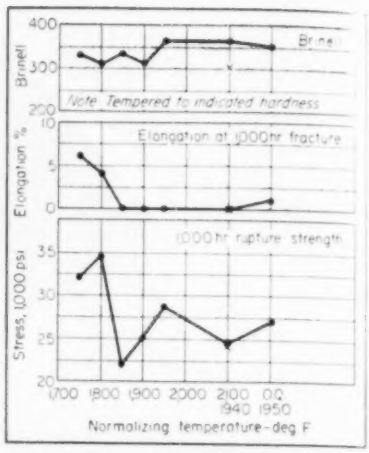



**FIG. 2—Effect of heat treatment on 1,100 F rupture strength, elongation and hardness of 17-22V steel (Heat A80).**

furnace heat was made, cast into a 14 in. ingot, forged to 7 in. square bloom and then upset forged into 22 in. dia pancakes, by 2 in. thick.

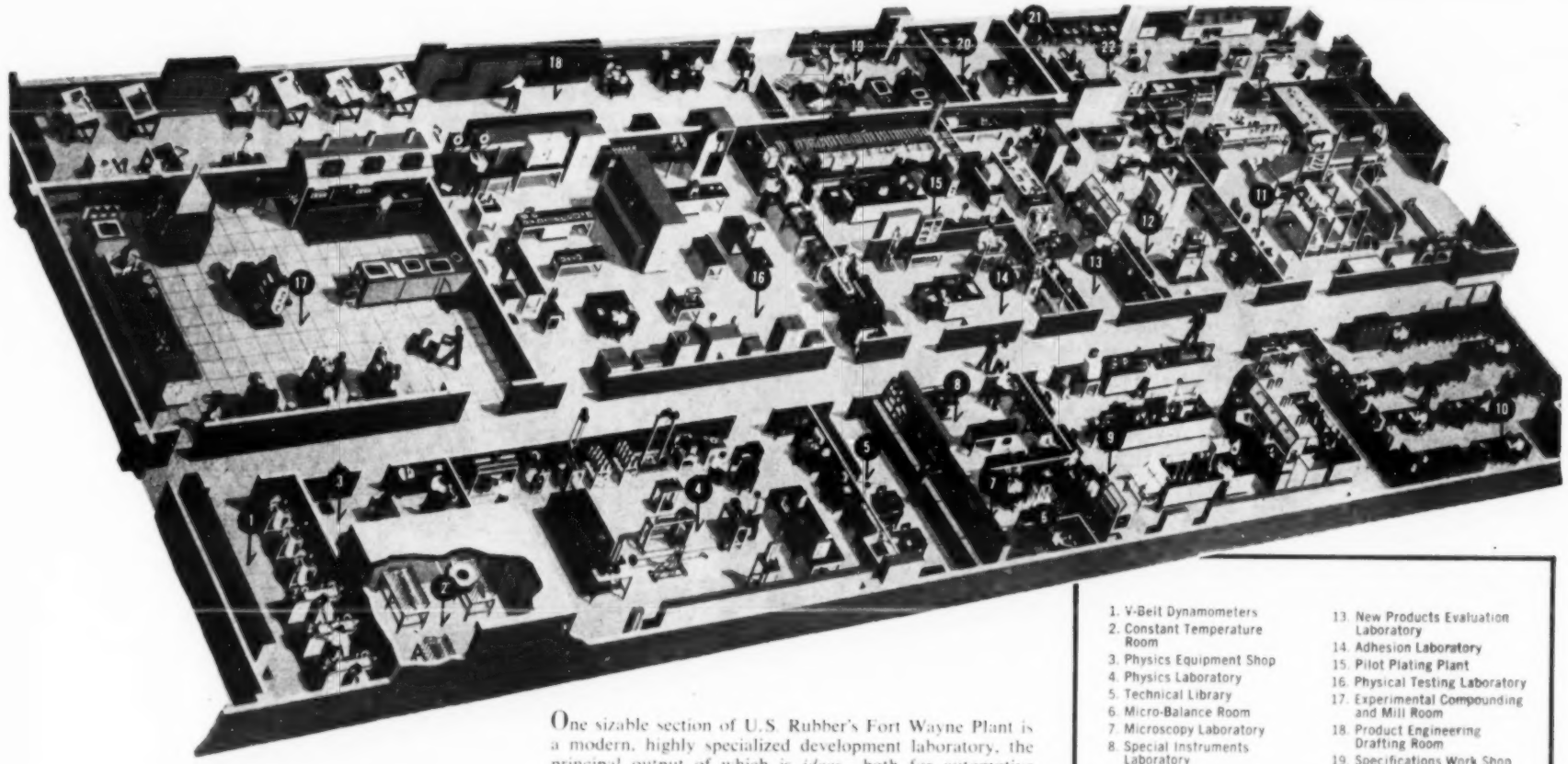
The pancake forgings of 17-22V were then heat treated by normalizing from 1,800 F and tempered to 323/337 Brinell. The hardness throughout the section was very uniform, thus indicating sufficient hardenability to permit normalizing sections of at least this size.

Tests were conducted at room temperature and 1,100 F on specimens cut from this forging and the results obtained, together with those from the 1 in. dia bar stock, were tabulated. For the given hardness level the room temperature physical properties of the heat treated forging are very acceptable and the 1,100 F rupture strength is even somewhat superior to that of the bar stock. (37,000 psi compared to 35,000 psi in 1000 hr test).

On the basis of these results two conclusions appear to be in order. First, that columbium must be present to obtain the greatest rupture strength at 1,100 F, and second, that higher than normal solution temperatures must be used in either the normalizing or quenching treatment.

The results show that low-alloy steels are available for relatively short life applications under high stress at 1,000 and 1,100 F. On the basis of 1,000 hr rupture, the maximum stress level at 1,000 F is 60,000 psi. At 1,100 F, 35,000 to 37,000 psi represents the maximum stress level.

17-22A(S) steel is believed to be the most suitable for service at 1,000 F under the given conditions. Its total mean alloy content is only 2.0 percent, it is free of nickel and contains only 0.50 molybdenum. Its



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1,000 hr rupture strength at 1,000 F is 60,000 psi.

On this same basis, 17-22V is believed the most suitable for service at 1,100 F. Its total mean alloy content is 2.55 pct. It is also free of nickel and contains only 0.50 molybdenum. It differs from 17-22A(S) in that its carbon content is 0.20, rather than 0.30, and its vanadium content 0.80, rather than 0.25. Its 1,000 hr rupture strength at 1,100 F is 35,000 to 37,000 pounds per square inch.

## Electronic Ferrite Applications

Abstracted from Ferrite Applications in Electronic Components by B. V. Vonderschmitt, M. J. Obert and H. B. Stott, Electronics, March 1952.

RECENT YEARS have seen an increasing use of ferromagnetic spinels, commonly called ferrites, in electronic components to replace silicon-steel laminations, iron wire and powdered iron and to provide components having improved characteristics and reduced bulk.

Characteristics of ferrites such as high maximum permeability, high electric resistivity and low r-f losses, are of particular interest for television components such as yokes and horizontal-deflection output and high-voltage transformers. In such components, the use of ferrites has made an important contribution to increasing operating efficiency and reducing size.

### Deflection Transformers

The high power required for deflection in wide-angle kinescopes necessitates the use of efficient deflection systems.

The single item used in the design of a horizontal-deflection output that determines its efficiency is the magnetic material used for the core. Ferrites have been developed exhibiting characteristics that are very favorable as core material for such transformers. As a result such transformers, operating from a moderate power supply with only a single high-voltage rectifier and capable of deflecting kinescopes having a 66-deg horizontal-deflection angle at anode voltages up to 18 kv, have been designed with small C-shaped ferrite cores. The total weight of the ferrite core for such a transformer is approximately 75 grams.

Compact ferrite cores also permit the use of compact coils having high coupling coefficients between primary and secondary windings. They have also made an important contribution

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- STRAIGHTENING

Ground and Polished STRESSPROOF has been used for lead and feed screws by Kearney & Trecker since 1939. If STRESSPROOF were not available, they would need a .50% carbon-alloy steel to obtain the required strength and wear-resistant properties. The substitution of alloy would require quenching, tempering and straightening—operations not necessary with Ground and Polished STRESSPROOF. The cost of the part would be more than doubled.

For precision work, lead and feed screws for machine tools must maintain their accuracy through years of operation. Ground and Polished STRESSPROOF cuts cost for these exacting parts because it provides *five* qualities in the bar—(1) *high strength*, double that of ordinary cold-finished shafting; (2) *machinability*, fully 50% better than heat-treated alloys of the same hardness; (3) *high resistance to wear*, replacing many heat-treated or carburized alloys; (4) *minimum warpage*, obtained by special processing; and (5) *accurate, finely ground surface*.

It is significant that the only suitable substitute for STRESSPROOF is an alloy steel requiring many additional expensive production operations.

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## Technical Service Data Sheet
## Subject: RUST PROOFING WITH PERMADINE®

### INTRODUCTION:

Ferrous metal parts that have been Permadized in a zinc phosphate chemical solution and then "sealed" with a rust-preventive oil such as "Granoleum" are effectively protected from rust-damage. In addition, if the surface is accidentally chipped or scratched, rusting is confined to the exposed area.

Rust proof coatings find many practical applications. During World Wars I and II most small arms were rust proofed by phosphate coating and impregnated with chromic acid and a rust preventive oil, or cutback petrolatum. This not only provided excellent corrosion resistance but also yielded a dull black non-reflecting surface. Rust proof finishes are now used widely on hardware, firearms, cartridge clips, metallic belt links, miscellaneous forgings and castings, tools, unpainted replacement machine parts, and many other similar items such as bolts, nuts, and washers.

### THE PERMADIZING PROCESS:

For the most effective rust proofing of large or small work in large or small production, "Permadine" is used in tanks in an immersion process, with the bath heated to 190°-210°F., coating time 20 to 30 minutes. The coated parts are then rinsed in clean water, and then in a controlled dilute acidulated solution. After drying, a suitable corrosion-resistant oil such as "Granoleum" is applied.

Operations can be carried out with the work in crates, or hung from hooks, utilizing an overhead rail and hoists. For large volume production, automatic equipment can be used to mechanize the line. Small parts can be treated in tumbling barrels.

### "PERMADINE" MEETS SERVICE SPECIFICATIONS:

The protective "Permadine" finish meets U.S.A. 57-0-2C; Type II, Class B, and equivalent requirements of:

MIL-C-16232,
Type II
U.S.A. 51-70-1,
Finish 22.02, Class B
AN-F-20
Navy Aeronautical M-364
JAN-L-548

### "PERMADINE" DATA CHART

| | |
|---|---|
| Type of coating | Zinc phosphate |
| Object of coating | Rust and corrosion prevention |
| Typical products treated | Nuts, bolts, screws, hardware items, tools, guns, cartridge clips, fire control instruments, metallic belt links, steel aircraft parts, certain steel projectiles and many other components |
| Scale of production | Large or small volume; large or small work |
| Method of application | Dip<br>Barrel tumbling, racked or basketed work |
| Equipment notes | Immersion tanks of suitable capacity. Cleaning and rinsing stages can be of mild steel. Coating stage can be of heavy mild steel or stainless steel. |
| Chemicals required | "Permadine" No. 1 |
| Pre-cleaning methods | Any common degreasing method can be used. Alkali cleaning ("Ridosol"), Acid cleaning ("Deoxidine"), Emulsion-alkali cleaning ("Ridosol"-"Ridoline"); vapor degreasing, solvent wiping, etc., are examples. Acid cleaning may need to follow other cleaning methods if rust or scale is present. |
| Bath Temperature | 190° - 210°F. |
| Coating time | 20 - 30 minutes |
| Coating weight range Mgs./Sq. Ft. | 1000 - 4000 |
| Technical Service Data Sheets | No. 7-20-1-2<br>T. M. No. 5 |

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in the design and development of deflecting yokes for scanning wide-angle picture tubes. For the flux-return path in these yokes, the ferrites provide a high-permeability low-loss magnetic material that is superior to early powdered-iron cores, and iron core wires.

### Ferrite Rod Antenna

Another application in which the use of ferrites has resulted in improved physical and electrical characteristics is in the antenna of small personal radio receivers.

This complete antenna occupies less than two square inches in area and in a confined space, as compared with the conventional loop antenna greater than 20 square inches in free space.

For optimum performance, the small coil and the $\frac{1}{4}$ by 7 in. rod should have the highest possible Q when in its mounted position. The rod must possess low-loss characteristics and high permeability. The pickup ability of the antenna and the signal-to-noise ratio of the receiver are dependent on these two basic criteria, on the resultant tuned-circuit impedance and on certain other design considerations such as the type of wire, winding and form factor of the coil on the ferrite rod.

For a given ferrite rod, there is a particular combination of size, shape and winding pitch factor that, along with the correct ratio of coil diameter to rod diameter, results in maximum pick-up voltage. These factors determine the degree of coupling to the rod and the amount of signal flux leakage and self-inductance leakage. Eddy-current losses between adjacent turns and also the distributed capacitance of the winding are reduced by the use of the progressive universal-type winding with 15/43 E.S.S. wire.

The positioning of the coil on the rod is also important. Losses due to ferrous metals close to the rod reduce the Q of the complete assembly; the

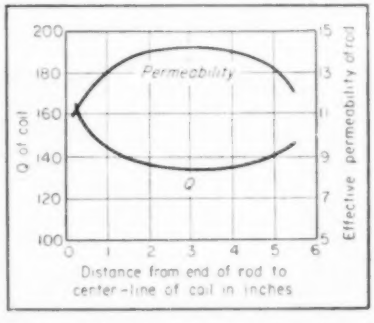
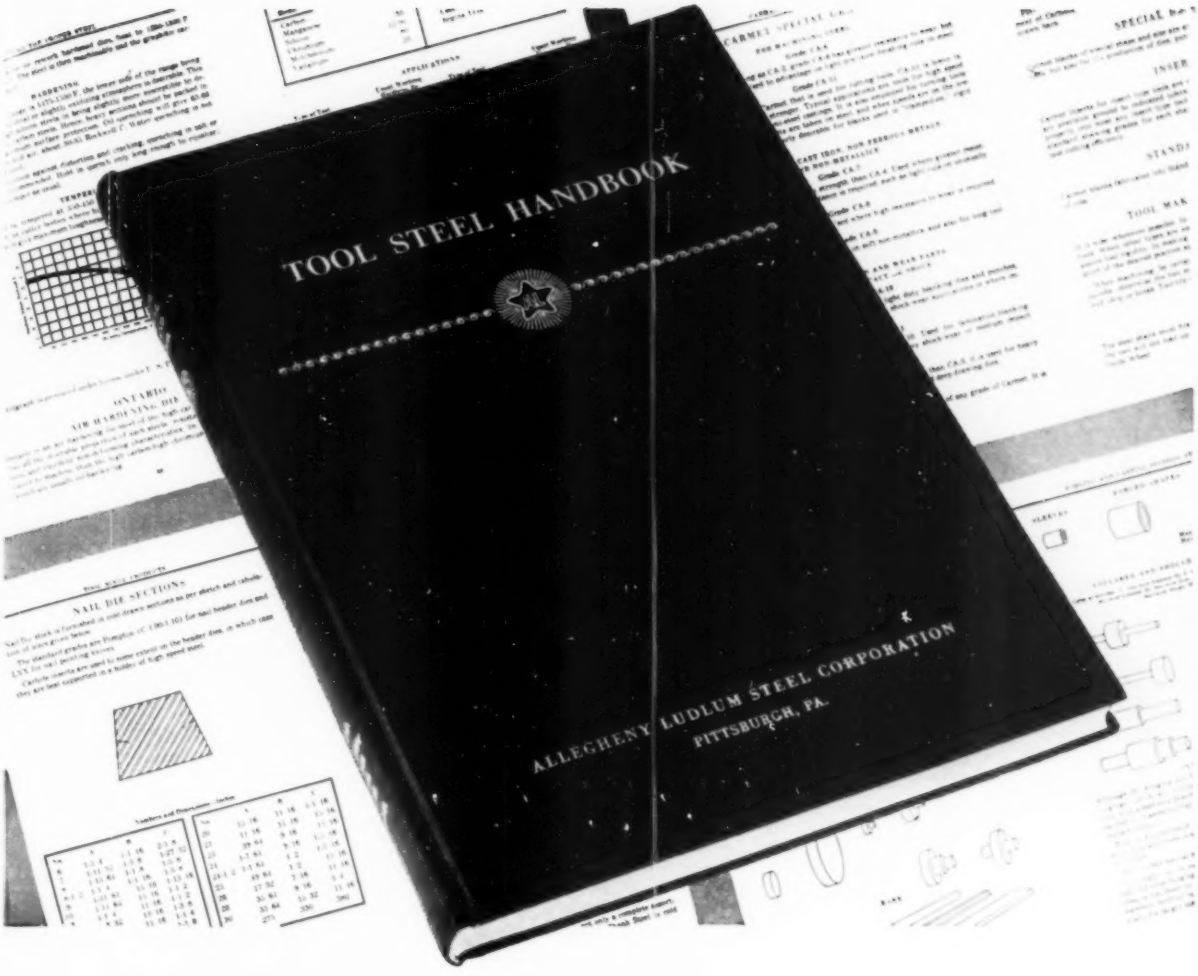



FIG. 1—Variation in Q of coil and permeability of ferrite rod with position of coil from the end of the rod.

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Technical Service Data Sheet
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**INTRODUCTION:**

Ferrous metal parts that have been Permadized in a zinc phos solution and then "sealed" with a rust-preventive oil such as are effectively protected from rust-damage. In addition, if the dentally chipped or scratched, rusting is confined to the expose

Rust proof coatings find many practical applications. During I and II most small arms were rust proofed by phosphate coatin nated with chromic acid and a rust preventive oil, or cutback pe not only provided excellent corrosion resistance but also yielde non-reflecting surface. Rust proof finishes are now used widely firearms, cartridge clips, metallic belt links, miscellaneous forg ings, tools, unpainted replacement machine parts, and many items such as bolts, nuts, and washers.

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For the most effective rust proofing of large or small work in production, "Permadine" is used in tanks in an immersion pro bath heated to 190°-210°F., coating time 20 to 30 minutes. Th are then rinsed in clean water, and then in a controlled dil solution. After drying, a suitable corrosion-resistant oil such as is applied.

Operations can be carried out with the work in crates, o hooks, utilizing an overhead rail and hoists. For large volum automatic equipment can be used to mechanize the line. Small treated in tumbling barrels.

**"PERMADINE" MEETS SERVICE SPECIFICATIONS:**

The protective "Permadine" finish meets U.S.A. 57-0-2C; Type II, Class B, and equivalent requirements of:

MIL-C-16232, Type II
U.S.A. 51-70-1, Finish 22.02, Class B
AN-F-20
Navy Aeronautical M-364
JAN-L-548

**"PERMADINE" DAT**

| | |
|---|---|
| Type of coating | Zinc phosphate |
| Object of coating | Rust and corrosio |
| Typical products treated | Nuts, bolts, screws tools, guns, cartrid trol instruments, n steel aircraft parts, jectiles and many |
| Scale of production | Large or small vol large or small wor |
| Method of application | Dip<br>Barrel tumbling, ra work |
| Equipment notes | Immersion tanks of Cleaning and rinsi of mild steel. Coatir heavy mild steel c |
| Chemicals required | "Permadine" No. |
| Pre-cleaning methods | Any common degrea be used, Alkali cl sol"), Acid cleaning Emulsion-alkali clea "Ridoline"); vapor vent wiping, etc., Acid cleaning may other cleaning met scale is present. |
| Bath Temperature | 190° - 210°F. |
| Coating time | 20 - 30 minutes |
| Coating weight range Mgs./Sq. Ft. | 1000 - 4000 |
| Technical Service Data Sheets | No. 7-20-1-2<br>T. M. No. 5 |

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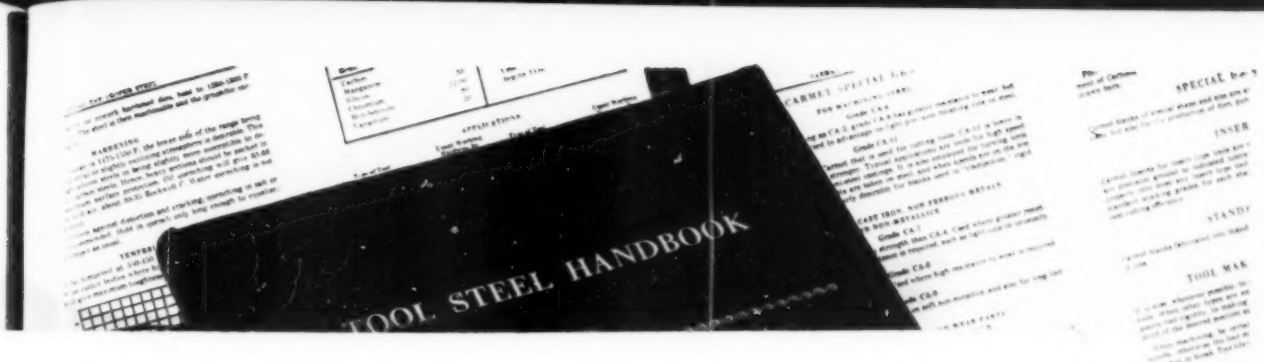
in the design and development of deflecting yokes for scanning wide-angle picture tubes. For the flux-return path in these yokes, the ferrites provide a high-permeability low-loss magnetic material that is superior to early powdered-iron cores, and iron-core wires.

FIG. 1—Variation in Q of coil and permeability of ferrite rod with position of coil from the end of the rod.

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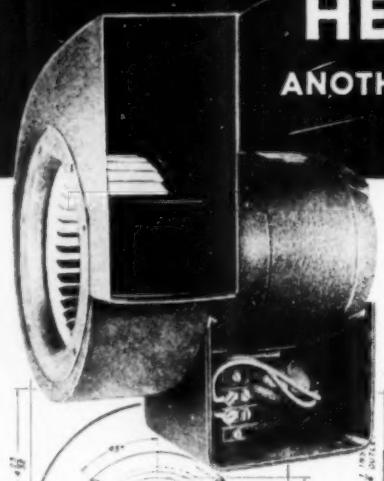

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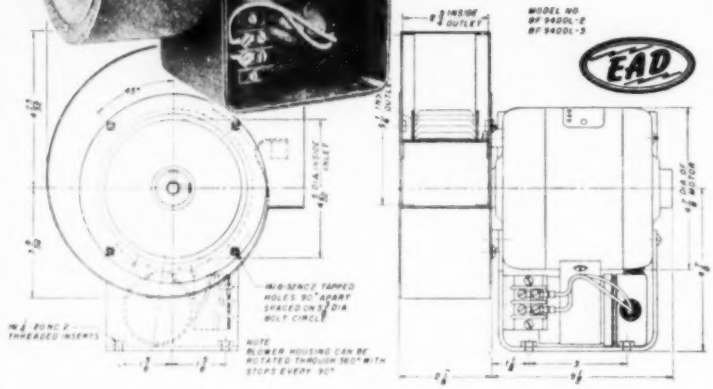


**SPECIFICATIONS**

MODEL NUMBER.....BF 94 DDL-2

CAPACITY..250 CFM at .5" Static Pressure NAFM
330 CFM at .0" Static Pressure

MOTOR *(Self Cooling—Completely Enclosed)*
⅛ H.P., Capacitor Induction,
120 Volts, Single Phase, AC,
60 Cycles, 3200 RPM,
Clockwise or Counter Clockwise.

MOUNTING .....Rigid Base

OVERALL
DIMENSIONS .....7 27/32" x 8 3/8" x 10 1/8"

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loss is greatest when the metals are close to the coil winding. Nonferrous metals induce less loss into the antenna but offer some shielding to magnetic pickup. Fig. 1 shows the effects of rod position.

Another feature due to the smallness of the ferrite antenna is its low distributed capacitance of only two μμf as compared with 14 μμf for conventional loops. With this lower capacitance, it is possible to obtain a higher tuned-circuit impedance because a smaller capacitance range is needed in the ganged-tuning capacitor and a greater value of coil inductance may be used.

The sensitivity of the antenna increases with the number of turns making up the antenna inductance. With the ferrite antenna, the reduced capacitance requirements make possible the use of a compact tuning capacitor having increased plate spacing.

### Ferrite-Rod Dimensions

The length of the ferrite rod has an effect on both the Q of the antenna and the effective permeability. Fig. 2 shows variation in Q with incremental increases in the length of the ferrite rod. This variation is due to the greater inherent losses in the longer rods coupled into the antenna coil. Also shown in Fig. 2 are the variations in effective permeability and the relative voltage pickup with rod length. The voltage pickup varies almost directly with rod length and approximately as the square of the rod diameter.

Fig. 3 shows the variations with frequency of Q and effective permeability of an antenna having the

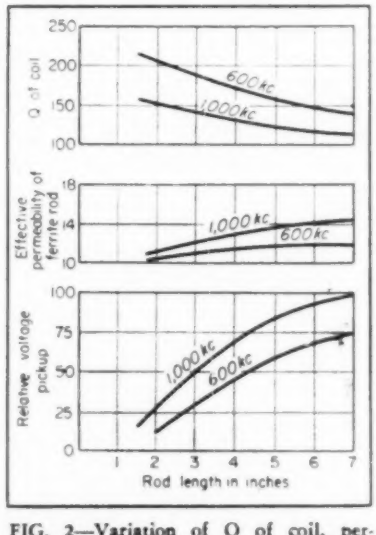


**FIG. 2—Variation of Q of coil, permeability of ferrite rod and voltage pickup of antenna with rod length.**

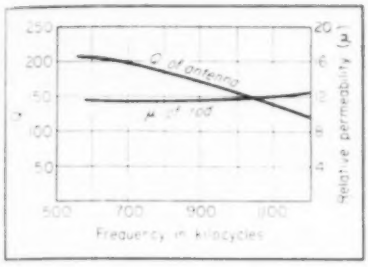


FIG. 3—Variation of Q of antenna and permeability of rod with frequency.

antenna coil located with its center line one inch from the rod end, the normal operating position. The signal-to-noise ratio of the antenna is improved over that of the conventional loop due to the higher operating Q and the smaller physical size. The smaller size is significant because it reduces the electrostatic pickup.

## Metal Sealant

**Abstracted from "Sealing Metal With Metal" by D. W. Holmes, Tincher Products Company, Modern Metals, February 1952.**

ALTHOUGH FOUNDRY PRACTICE has generally improved of late, porosity is still a problem—and probably aways will be. When a cast product must be pressure tight to hold gases or liquids, porosity could cause rejection of the part. In many cases this porosity is not detected until the part is machined to its final form. Rejected castings at this stage are costly to the manufacturer. Control of this porosity metallurgically is usually difficult and inconsistent. It can often be prevented, however, by impregnating the casting; i.e., forcing some compound into the pores, thus sealing them off.

A metal-base material comes nearest to being the perfect sealant, inasmuch as it combines permanency with ease of application, and has the advantages of non-inflammability, no toxic vapors, cleans easily with water and is low in cost.

The sealing elements are various metallic oxides and other mineral particles as small as one millionth of an inch that penetrate the porous area of the metal and create a permanent seal. To carry these oxides into the porous voids of the casting, a vehicle capable of holding them in suspension is necessary.

A silicate, or combination of silicates, of soda is used. The function of the silicate of soda is two-fold; it not only holds the metallic oxides in suspension, but it helps to hold them

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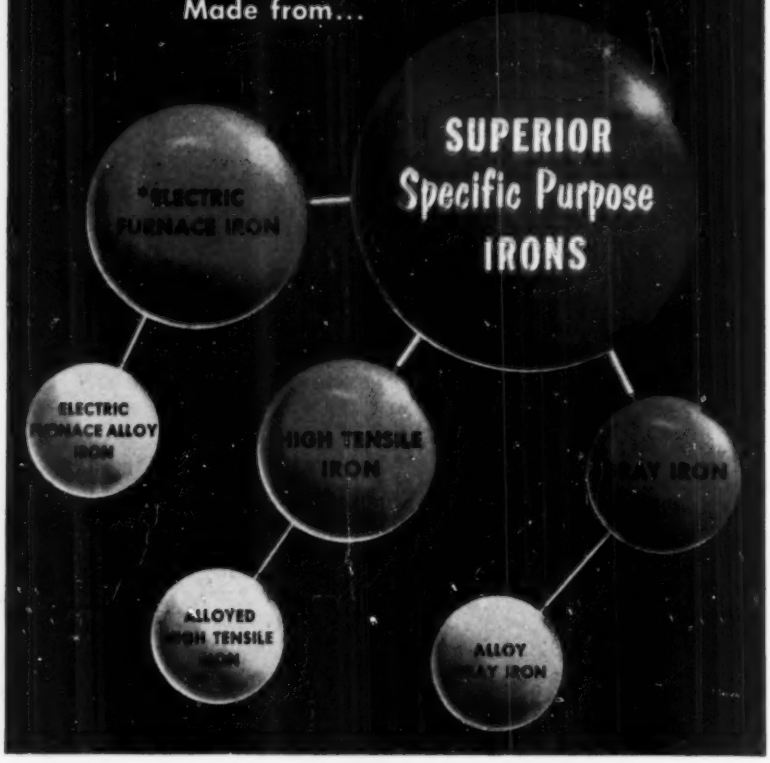


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in the porous section of the casti until the permanent seal is accomplished.

A line of impregnating equipment designed specifically for this type of sealing compound has been developed by Tincher Products Company of Sycamore, Illinois. Here is how this equipment is used.

### The Processing Cycle

First the castings are cleaned and degreased so that the seal will be able to wet the surface of the metal. Then they are placed in an autoclave. (If they are exceptionally large, internal circulation is used.)

The sealing compound, which has been heated to 180 F, is circulated over the castings for a period of time sufficient to bring them to a temperature equal to that of the seal. This heating expands the pores so that the entrapped gases will easily escape and the metallic oxides will enter the open pores.

After Operation No. 3 is complete, a pressure of 400 psi is applied and held for five to thirty minutes. The pressure is then released and the sealant is pumped back into the storage tank after which the castings are washed with plain cold water to remove signs of impregnation.

The impregnated castings are now permitted to air dry and to stand for a sufficient length of time so that the oxides trapped in the pores may further oxidize and expand. This expansion is the basis of the primary sealing, and the oxidation process is catalyzed or speeded up by the parent metal of the casting itself.

### Internal Impregnation

When large parts are to be sealed, internal impregnation is employed. This method is similar in basic essentials to the batch method, except that a circulator installation is used.

All parts or openings of the large casting are closed off with the exception of an inlet and an outlet. The sealing compound is circulated through the casting until it is brought up to the temperature of the compound. The outlet is then closed and pressure is exerted on the compound in the casting, thus forcing it into and through all porous voids in the metal.

This method is used to impregnate such parts as engine blocks, engine heads, hydraulic press cylinders, steam vessels and large water pump parts. A combination testing-impregnation operation is ideal where large individual parts are hydrostatically tested. A Tincher Circulator is hooked to the

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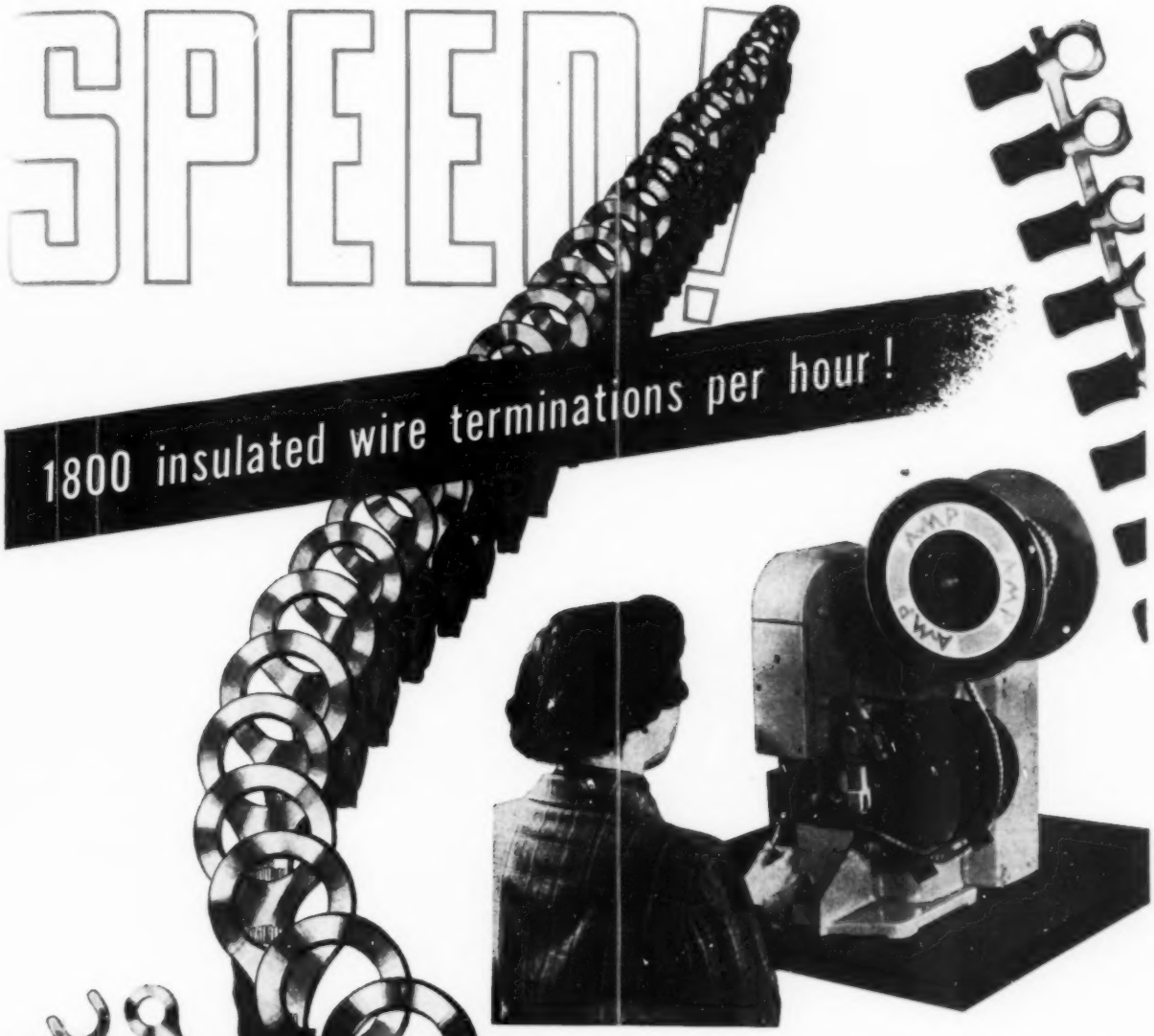

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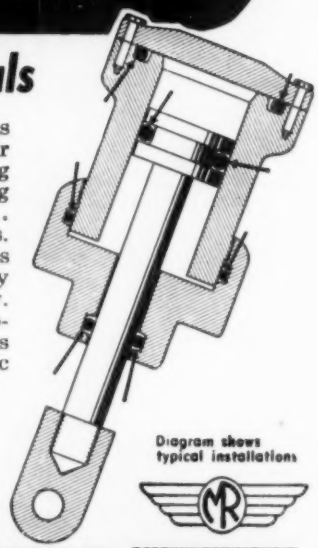

Diagram shows typical installations

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hydrostatic testing fixture, and Tincher Seal (180 F) is used as the testing agent. If a leak is found—evidenced by oozing of the Seal through the metal—the part is held under pressure for 15 seconds to 2 minutes.

Castings impregnated by the Tincher process can be subjected to any pickling or acid bath. The sealing compound has no effect on the machineability of the metal, and a cold water rinse is all that's needed to remove excess compound from the casting surface. The Tincher impregnation process may be applied to castings with baked-on enamel or nickel or chrome plate finishes.

The process is used by many large companies for the impregnation of aluminum, magnesium, and zinc die castings as well as for sand cast iron, steel, stainless, bronze, brass, aluminum, and magnesium. It has the approval of the Army, Navy and Air Force, and is being used on many government projects.

# *Sans, Souci*

### Ad Libbing by the Editor

There was a time when old man "Supply and Demand" had things pretty much his own way. But as our civilization became more complicated occasions arose wherein old man "Supply and Demand" did not work out so well. He caused a lot of unnecessary suffering and things sometimes got way out of line. So along came "controls" which are supposed to make old man "Supply and Demand" behave to better advantage of supposedly everybody. Then everything starts to get really complicated. Let's see how it works.

Engineering is a young profession and has been struggling many years for recognition. Even today it has extremely limited recognition when contrasted with the status of law, medicine, dentistry and certified public accounting.

Because the required degree of learning and training was not exceptionally great in the early days, the pay of engineers was based on supply and demand, with the supply being plentiful. Pay was low. Likewise the cost of an engineering education was relatively low. Then as the fund of engineering knowledge grew, the cost of the education went up. Today a four-year undergraduate course in engineering costs about $5,000 mini-

mum, plus the loss of earnings of the student. The total cost amounts to about $15,000 minimum. To amortize this investment requires payments of $75.00 per month for about thirteen years.

Today industry must have engineers. The success or failure of almost every manufacturing company depends basically on its engineering. Indeed, the productivity per man hour is limited only by the efficiency of the design of the production machinery. Today design represents a many times greater portion of the cost of the product than it did thirty years ago. Engineers are essential. Improvement in our material welfare depends almost entirely upon them translating the discoveries of science into usable products. More and more engineers are required, be it peace time or war.

Admittedly accentuated by the decrease in the number of graduates annually, we have a great shortage of engineers today. Old man "Supply and Demand" has operated to increase salaries of new graduates about fifty percent. Engineers with varying years of experience also received increases, many of them by switching jobs. The shortage became more acute. At last, by the grace of old man "Supply and Demand" it looked as if engineers would reach a salary level commensurate with a professional status. But then came controls.

In line with all other salaried personnel, engineers have their pay check "controlled" by government regulation under the Office of Salary Stabilization. According to government men, if it were not so engineering salaries would "go up through the roof", a contention that is wide open to question. Significantly, doctors and lawyers have been exempted by Act of Congress from salary controls. The shortage of dentists is comparable to that of engineers.

Apparently engineering is not classed as a profession in the eyes of the "authorities". Perhaps naturally so because the medical profession, and presumably the dentists also, have active representation in Washington to protect or further their interests. The American Medical Association has on many occasions brought heavy pressure to bear on federal law making bodies.

Only one of the many engineering societies has done anything substantial to further the economic status of the engineering profession. The National Society of Professional Engineers appeared before the Senate Banking Committee. That committee, in voting an extension of wage price controls beyond June 30, unanimously decided to exempt from salary controls architects, engineers and accountants employed by

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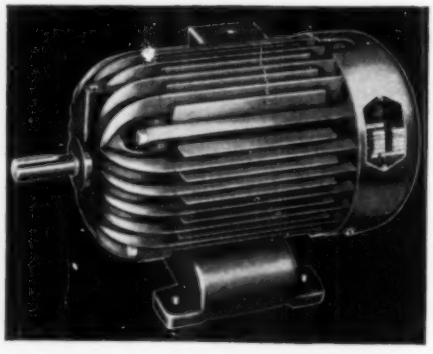

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Sans Souci . . . . . continued

consulting firms. The Office of Salary Stabilization, it is reported, is going to fight this tooth and nail. Give more power to the National Society of Professional Engineers by writing your senators and congressmen. Get all engineers exempted from salary controls.

How crazy can we get? Here at a time when we are urging high school boys to go to engineering colleges the government is virtually preventing engineers from receiving reasonable salary increases. Almost every high school boy knows that carpenters, bricklayers and electricians earn better than $7,500 a year and a locomotive engineer about the same, and that truck drivers get as much as $10,000 a year. An air line pilot receives $12,000 a year or more, and so on. The high school boys also know that the average engineer gets less than $4,000 a year on his first job and is considered a success if he gets $7,500 a year twenty years later. To prepare himself for such a "lucrative" job the high school student is urged to spend at least 4 years in college at a cost of $5,000 or more, plus his loss of earnings.

It is impossible to cover all the facets of this problem in a few columns of type. But in the light of what is developing it is obvious that: (1) Engineers are not organized on a professional basis that is conducive to improvement of their economic status. (2) The value of engineers and their earned position in the economic scale is not recognized by government legislators or bureaucrats. The engineers' status in that respect is about two steps below the level of organized labor. (3) Increased enrollment in engineering colleges cannot be expected if government controls tend to hold down engineering salaries. (4) The four large engineering societies, on the basis of their past record and because they will not engage in anything that smacks of politics, cannot be expected to be of any help in raising the economic level of engineers. (5) The National Society of Professional Engineers has done and is doing things to raise the economic status of engineers. That organization should be encouraged and supported. (6) Every engineer can do much toward getting professional recognition and status by writing his congressman and senators and urging them to support the unanimous decision of the Senate Banking Committee exempting architects, engineers and accountants employed by consulting firms, from salary control and urging the extension of this to all engineers regardless of by whom employed. —G.F.N.


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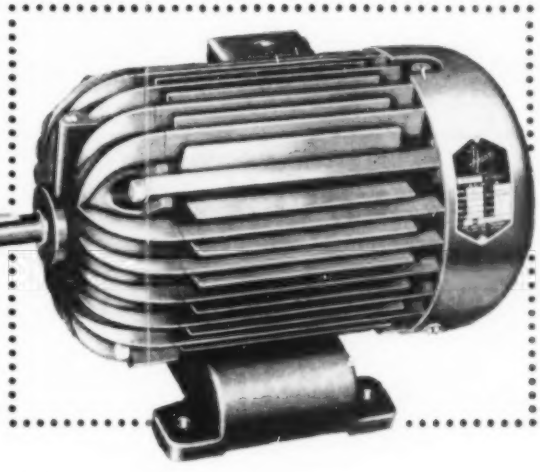

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# OUR READERS SAY

## An Old Typo Error

*To the Editor:*

I have PRODUCT ENGINEERING's chart of "Organic Finishes for Metal Products" which appeared in April 1951. One material title is listed as Phenolic anhydride—polyhydric alcohol-oil combustion. It seems to me that this is a misprint. It should be Phthalic anhydride instead of Phenolic anhydride. —LEO ABERBACH
*Springfield, Mass.*

Ed — Sharp-eyed reader Aberbach caught a typographical error. Phthalic anhydride is correct and should replace the title "Phenolic anhydride."

## Nylon Ball Bearing Parts

*To the Editor:*

We would like permission to reproduce the article "Nylon Parts for Ball Bearings" which appeared in the February 1952 issue of PRODUCT ENGINEERING for circulation among our Nylon molding customers.
—J. R. K. RUSSELL
*Plastic Engineers, Ltd.*
*South Wales, Great Britain*

Ed—We are happy to grant permission to reprint this, providing credit is given to PRODUCT ENGINEERING and the Schatz Manufacturing Company who originated the material.

## Drafting Standards Being Studied

*To the Editor:*

I noticed in your February 1952 edition of PRODUCT ENGINEERING on page 278, the Editors Note concerning Drafting Standards.

For your information and that of your readers, there is underway at this time, a new and revised Drafting Standard.

This standard is being written by a committee appointed by ASME and American Standards Association. It is divided into about 18 subcommittees of approximately 8 men each representing a cross section of industry from all over the country.

It is the hope of the committee that

this standard will fill a long felt need and will be universally used.

—BERNARD J. WOLFE
*The Haloid Company*

Ed—Many readers will be interested in following the progress of this committee's work.

## Legal Snarl Slows Ball Bearing Delivery

*To the Editor:*

For the past number of years we have been subscribers to your publication, PRODUCT ENGINEERING, and are writing to you to ask if you could help us.

We are desirous of purchasing a quantity of New Departure Ball Bearings, which are manufactured by a division of General Motors, Connecticut, U. S. A.

Some months ago we contacted the manufacturers in America, who referred us back to their agents, the Delco-Remy-Hyatt Co., Ltd., in London.

We placed our order for these bearings with Delco-Remy-Hyatt, who have not been able to supply us on account of certain unspecified formalities still outstanding between our two governments.

These bearings are for use on equipment we are building which has a direct bearing on the Rearmament Program in this country.

The division of General Motors will not of course supply us, as they will only deliver to their specified agents, and we are writing to ask you to locate these bearings in your own country.

We would be extremely obliged if you could let us know where we could purchase the bearings in question, and if possible the total amount of dollars involved.

The bearings we need are:

36 off. New Departure Bearings —Seal 88504.
18 off. New Departure Bearings —Seal 8506.
9 off. New Departure Bearings —Seal 88507.
300 off. New Departure Bearings —88016.
18 off. New Departure Bearings —Seal 88108.
45 off. New Departure Bearings —Seal 88506.

The position is so serious that we would consider sending one of our representatives over to America to pick up these bearings.

—*Bradwell, England*

Ed—Unfortunately there's not much we or General Motors can do for you.


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IF GEARS are a part of the machines you make, there is no finer recommendation for YOUR PRODUCT than to be able to say it is "Equipped with FAIRFIELD GEARS!"

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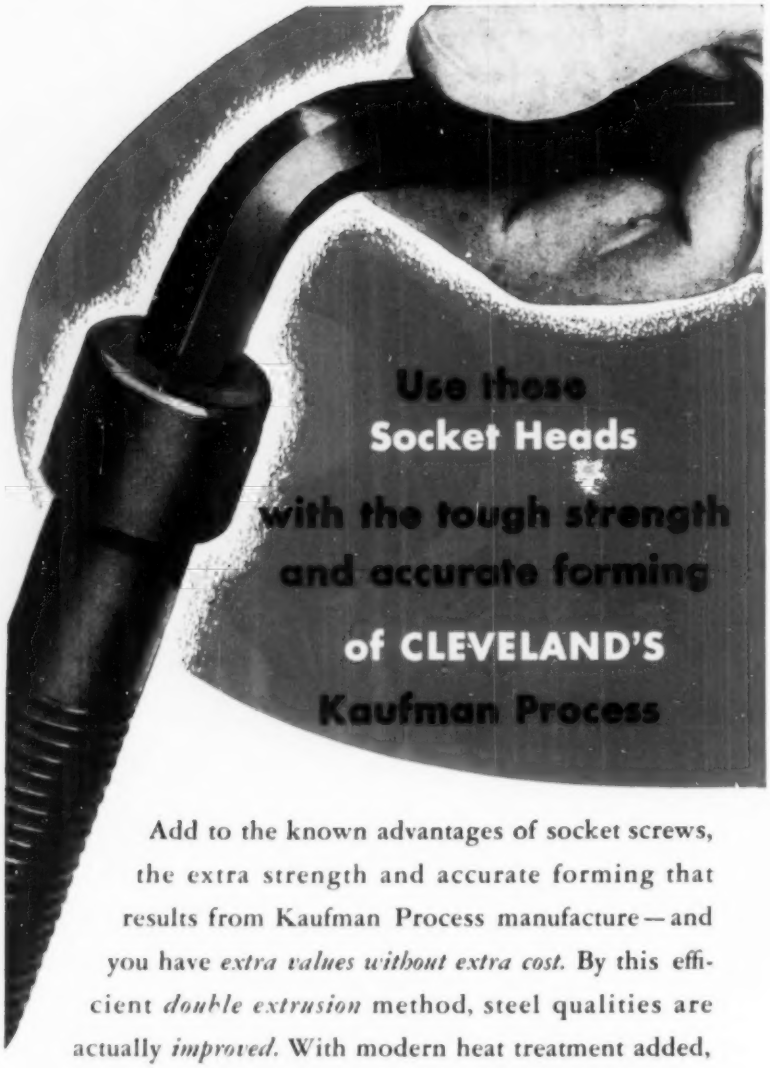


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Your first problem is one with the agency of the British government which handles import licenses. As we understand it, it is against British law for anyone to import any ball bearings without an import license from the government. If you can get such a license, the New Departure division has offered to expedite your order. GM suggests you contact their ball bearing sales organization in England, the Delco-Remy-Hyatt Co. And as soon as the license is granted, GM will accept a cabled order from Delco-Remy-Hyatt to speed up your delivery. Incidentally, they tell us that the bearings listed in your letter, come in several degrees of quality, that are indicated by suffixes to the numbers. These suffixes show various degrees of precision, tolerances in dimensions, etc. In view of this situation, it would be hardly worth your while to send a representative to the United States, since he wouldn't be able to bring the bearings back to England without an import license.

## Only the Profit Motive

*To the Editor:*

We would like permission to reprint the editorial from your November 1951 issue titled, "Only the Profit Motive Can Do It." The customary acknowledgement of the source will be given. —DAVID J. THOMAS
*Pittsfield General Electric Engineers Association*

Ed—We are pleased to grant you permission to reprint this editorial.

## Silicon Monoxide

*To the Editor:*

We are in urgent need of a supplier of Silicon Monoxide, SiO. Various local chemical suppliers have been queried without success. I am therefore hopeful you may know of a source for this element. It is desirable that a chemically pure grade of SiO is obtained.

Our prime use of SiO is for protection coating over aluminum coated front surface, glass optical mirrors. All processing of these mirrors is handled in vacuum bell jar. The protecting coat of SiO prevents formation of Aluminum Oxide and also retains the desired optical characteristics of mirrors. —JULIAN B. PINTO
*Northrop Aircraft, Inc.*

Ed—We were unsuccessful in finding a supplier of SiO, since most chemical

# WHAT CAN ZINC DIE CASTINGS DO FOR YOU —*right now?*

If you are now using ZINC Die Castings in your products read no further—you know what follows.

You who have products requiring metal parts may be overlooking an obvious means of materially lowering production costs if you have not fully investigated ZINC Die Castings. Those product designers who utilized this metal and method of production to the tune of 225,000 tons of castings last year, did so for a simple reason—they did the job best at the lowest possible cost. Low price tags are the key to *selling* the huge quantity of goods industry is now capable of producing.

The economy of this means of manufacture lies in the high speed with which almost finished parts can be produced by one man operating a single die casting machine. The approximately 300 "gates" shown above were cast in this plunger-type machine in one hour—and each "gate" contains 6 different castings. *Thus the production is at the rate of 1800 castings per hour!*

ZINC Die Castings are produced so close to finished form and detail that little or no machining is required. Furthermore, the ability to cast complex shapes means that one part can frequently serve in place of several. This, plus the fact that mounting elements can be integrally cast, greatly minimizes assembly costs.

Add to the foregoing the dimensional accuracy and unusual physical properties of ZINC Die Castings and you have the principal reasons why you should consult a commercial die caster as soon as possible—or write to us.

**The New Jersey Zinc Company, 160 Front St., New York 38, N. Y.**

**ZINC**
**FOR DIE CASTING ALLOYS**

**The Research was done, the Alloys were developed, and most Die Castings are based on**

**HORSE HEAD SPECIAL (99.99 + % Uniform Quality) ZINC**

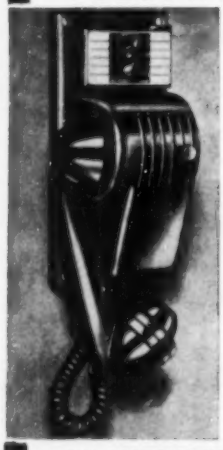
WITHOUT TALKING BACK TO CUSTOMERS

Wheeler Sound Powered Telephones do a triple job of time-saving, work-speeding and good customer relations in Boston and Connecticut areas of the First National Stores.

Specially adapted to tie in with the store intercom and loud speaker systems, Wheeler units permit Meat and Produce Managers to communicate with wrapping and supply departments without having noisy (and possibly "rough" conversation carried back over loudspeakers to be heard by customers.

Many installations of Wheeler Sound Powered Telephones stress this important feature of privacy. All stress economy, dependable operation, complete freedom from maintenance, no outside power source. Write us for literature.

**WHEELER**
**SOUND POWERED TELEPHONES**



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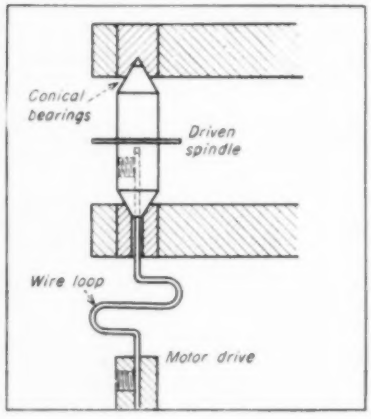
companies feel that it is too unstable for commercial handling. But it is used in the manufacture of abrasives, so we suggest you contact an abrasive maker (like the following) and they may be able to help you find a supplier: Norton Company, Worcester, Mass.; Carborundum Co., Niagara Falls, N. Y.; Philadelphia Quartz Co., Philadelphia, Penna.

## Low Cost Coupling For Small Diameter Shafts

*To the Editor:*

During recent years, we have obtained good results by using a thin wire band in the form of a loop to couple a 1/10 hp motor to a diamond sawing machine. As shown in the accompanying sketch, the saw spindle rotates in conical bearings; spindle speeds range up to 8,000 rpm. As compared with a number of alternative methods, the wire loop transmits a minimum amount of vibration. In




addition when using the wire loop coupling, it is not necessary to mount the saw on a concrete bed as is customary when using a flat belt drive. The wire loop coupling has also been used to drive micro-abrasion testers over a 10,000 to 20,000 rpm speed range.

—P. GRODZINSKI
*London, England*

## Phosphate Coatings

*To the Editor:*

We have been quite interested in getting additional information on phosphate coatings and have just finished reading your very complete article on this in the February issue. We are at a loss in trying to go from the government specification number to the various trade names for these coatings and wonder if you could

**TMI Specializes in Cold Drawn One-Piece Stainless Steel**

**Bulb-Capillary Units** "Extensive research and production tests on all 12 types of Stainless Steel Tubing prove the advantages of our unique method of cold-drawing bulb capillary units: SMOOTH inside and outside surfaces and an absolute elimination of uncontrolled inside surfaces, leaks and "welding" failures. This TUBE METHODS development means extra economy, too. It will pay you to write for quotations on YOUR specific Bulb Capillary Unit requirements."

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METALLURGISTS • ENGINEERS • MANUFACTURERS
BRIDGEPORT (Montgomery County), PA.

furnish us enough of such information that we can go to the original manufacturer for further details. We are particularly interested in protecting some high grade steel used in the oil fields and also in protecting a cadmium or zinc coated surface. We also need information on protecting aluminum. —D. O. JOHNSON
*Johnson-Fagg Engineering Co.*

Ed—The author of this article, Mr. Norman P. Gentieu of the American Chemical Paint Co., Ambler, Pa., will be pleased to supply all the information you requested.

## Who Uses Computers?

*To the Editor:*

I have read with interest the article on the Resistance Wire Equation-Solver in the February issue, and should like to request certain information regarding such computers in general.

We have developed a successful test model of an equation-solver based on a new principle involving multi-coil transformers, which, as its principal advantage, requires no balancing or iterative adjustments. If we could contact possible users of such a device and gage the commercial possibilities, we might see our way clear to the construction of full-fledged working models.

I would therefore appreciate it if you could inform us as to where in science and industry such a device would be used. The names of specific organizations would of course be particularly helpful.
—FREDERICK L. RYDER
*American Hydromath Corp.*

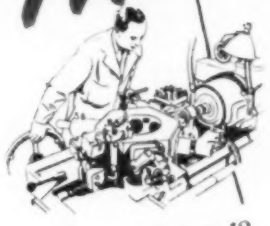
Ed—It's pretty difficult to list actual companies who might be interested in such a device. Computers are solving daily problems in practically every aircraft plant in the country. Government agencies doing research and design in aviation, ships, electronics, ballistics, and guided missiles use these computers also. High speed machinery manufacturers are another possible big user for vibration studies.

## Light Metal Alloys

*To the Editor:*

In the February 1952 issue of PRODUCT ENGINEERING we read with interest the article titled "Flux Bath Dip Brazing of Aluminum Alloys" by Mr. D. Wallace of the Sperry Gyroscope Company. In particular, we were interested in the reference made to sev-

METAL-W[illegible]ING'S
Master Clutch

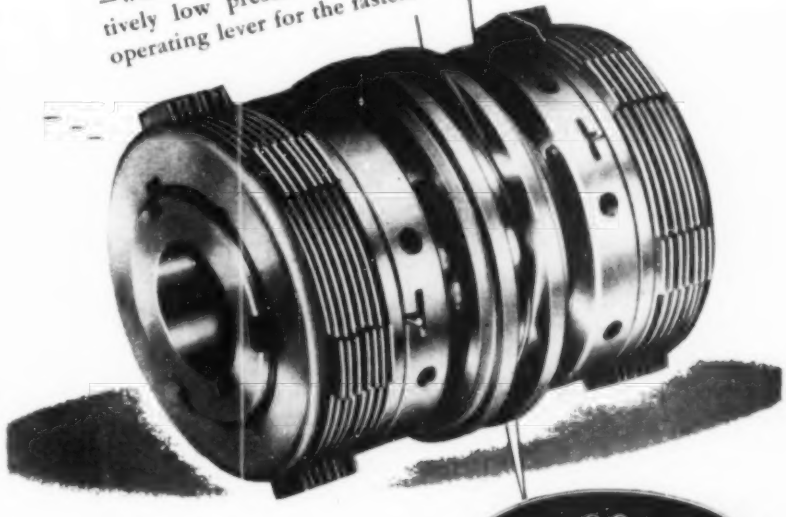


It would be interesting to speculate on how much of America's total metal-working production is on machines which are "put to work" through Twin Disc Machine Tool Clutches. For these units have so well proved their efficiency that almost every leading machine tool manufacturer in the country employs them on one or more models.

These clutches are unaffected by centrifugal action. They connect and disconnect —without lag—with comparatively low pressures on the operating lever for the fastest of work cycles. They're conservatively rated to assure the longest of wear life, with simple, single-point adjustment when needed.

Moreover, they are designed to work in very limited space and transmit, with positive clamping action, a high amount of torque. For all the reasons why Twin Disc Machine Tool Clutches—duplex or single, oil type or dry type —are the industry's standard, write today for Bulletin No. 134-A.

Fast, lag-free operation, in a compact, high torque capacity clutch is assured with Twin Disc Oil Type or Dry Type Machine Tool Clutches, offered in a complete range of capacities.



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Clutches & Hydraulic Drives

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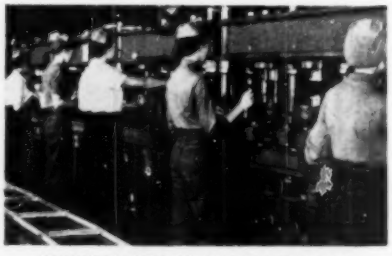

MODERN PRODUCTION MACHINERY

ALBERT TROSTEL & SONS COMPANY
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eral types of aluminum-zinc-magnesium alloys for casting.

We feel that we have a need for material of this type and would appreciate receiving help from you as to where we may contact the producers of these materials. The trade names of the materials involved are: A612 Ternalloy 8; and Tenzalloy.

—E. A. RANSOM
*Aero-Coupling Corp.*

Ed—The names and addresses of the suppliers of these alloys are:

A612—Aluminum Company of America, Pittsburgh 19, Pennsylvania.

Ternalloy 8—Apex Smelting Co., 6700 Grant, Cleveland, Ohio.

Tenzalloy—Federated Metals Division, American Smelting and Refining Co., Perth Amboy, New Jersey.

## Heat Resistant Adhesives

*To the Editor:*

Please indicate brand names and manufacturers of "Heat Resistant Adhesives" as described on page 200 of the February 1952 issue of PRODUCT ENGINEERING. —H. H. FURN
*Thomas A. Edison, Inc.*

Ed—We cannot give you any brand names on these materials, but the adhesives described were developed and are being used by General Motors. They were developed by Mr. A. J. Kearfott and Mr. C. W. Roush at the General Motors Research Laboratories in Detroit, Michigan.

# ERRATA

Jan., 1952 Page 150. *Diesel Engine Cooled by Forced Air.* Cologne, Rhine is an incorrect address for Kloeckner-Humboldt Deutz A. G. The correct address is Cologne, Germany. Inquiries may be sent in the United States to the Diesel Energy Corp., 47 West St., New York 6, New York.

Feb. 1952 Page 242. *Surface Temperatures Accurately Checked.* The Phaostron Company was incorrectly listed as the supplier of this thermometer. Correct supplier is the Pacific-Transducer Co., 11921 West Pico Blvd., Los Angeles 64, California.

March, 1952 Page 218. *Nema Frame, Face Mounted, Integral Hp Motors.* Address of this supplier is not 360 N. Michigan Ave., Chicago, Illinois. Correct address is the Hoover Company, 8 So. Michigan Ave., Chicago 3, Ill.

# DIE CASTING cuts costs 66⅔%

CASE HISTORIES FROM MT. VERNON FILES

Seeking to lower manufacturing costs without any sacrifice of product quality, Jaen Electromotive Corporation, of Long Island City, N. Y. gave die casting a chance to solve the problem of producing gear-train housings for synchronous motors. Previously, such housings had been sand cast.

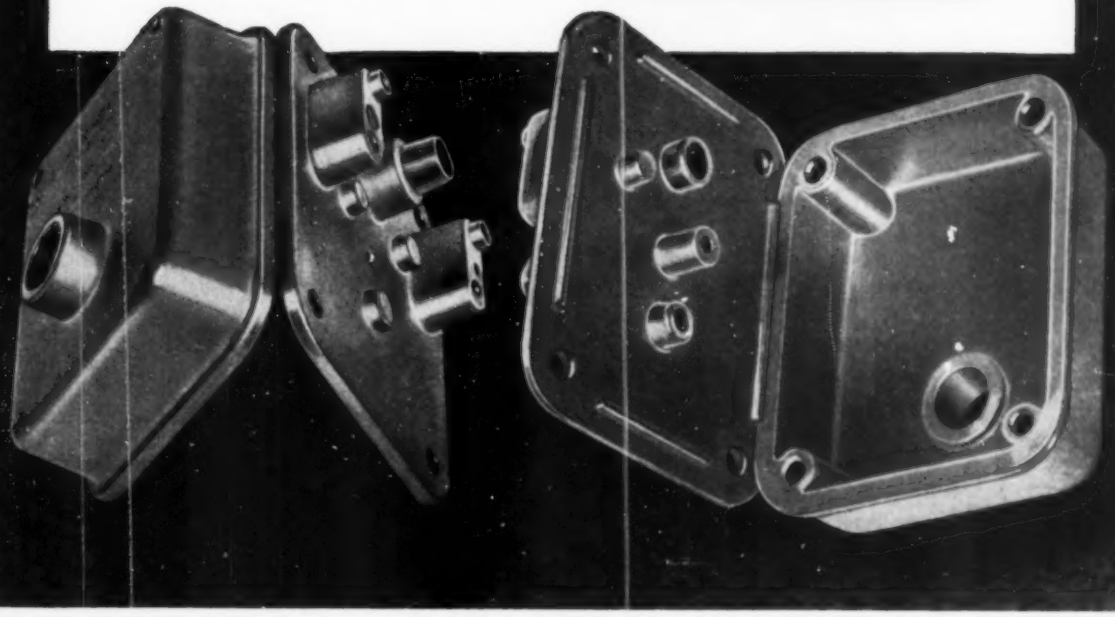
The result of the experiment is that Jaen *now specifies die casting*. For it has found: (1) the "clean" die castings produced by Mount Vernon cut machining costs over 50%; (2) an etched name-plate can be eliminated, since die casting permits company name and motor specifications to be clearly cast into the housing; (3) over-all appearance of the die cast units is decidedly superior.

Added to these advantages, are those realized *on the spot*, as the casting is made. Namely, *extremely fast production*, since die cast items are produced virtually in one operation, as the die closes; and *savings in material*.

Says Jaen Electromotive Corporation: "The over-all cost of the die castings is only *one-third* that of the machined sand cast aluminum pieces initially used. We shall be able to reduce our list price on this type of unit, and increase sales appreciably."

The next time *you* have to select a manufacturing procedure, remember this example of remarkable savings made possible by die casting — and consult with us. We shall welcome the opportunity to help you increase your output, improve your products, and *hold down your production costs*.

**MT. VERNON**
**DIE CASTING CORP.**
MT VERNON NEW YORK



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*Their future is based on decisions made today. The secret of success at Indiana Gear is to visualize . . . create . . . prove . . . and then move on to conquer the next problem. Indiana Gear proves from past success in a highly competitive business that its policy of using master craftsmen, fine equipment, skilled sub-contractors, and "young men of vision," exemplifies the perfectly coordinated planning so necessary to solve the gear problems of today.*

**INDIANA GEAR**

The driven gear shown here is 5" in pitch diameter and 15" long overall. It is carburized and hardened with heat-treating distortion held within .001".

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# NEW BOOKS

## Symposium on Structural Sandwich Constructions

*114 pages, 6 x 9 in. Published by the American Society For Testing Materials, 1916 Race Street, Philadelphia Pennsylvania. Paper cover,* $2.

The eight significant papers and discussions comprising this publication were sponsored by ASTM Committee C-19 on Structural Sandwich Constructions and presented at the 1951 Annual Meeting of the American Society for Testing Materials.

Structural sandwich constructions, as usually employed, consist of laminated materials in which the faces are relatively thin, strong, and dense, whereas the cores are relatively weaker than the faces. The objective is to obtain a structure that is strong and stiff because of its construction, but is at the same time light in weight, or has other desirable attributes not obtainable with the components used singly.

The papers presented on this subject cover the various types of sandwich construction materials, their design, fabrication and applications. The authors are men well versed in this field.

This symposium was arranged to provide a wider acquaintance with sandwich constructions. The papers, with illustrations, numerous bibliographical references, charts and graphs, should be of particular value to those responsible for the design and construction of aircraft, large buildings, houses, etc., as well as those concerned with aluminum, wood, adhesives, plastics and fields of testing.

## Electrolytic Manganese and Its Alloys

REGINALD S. DEAN, *Met. E., Ph.D., Metallurgical Engineer and Consultant. Formerly, Chief Metallurgist and Assistant Director, U. S. Bureau of Mines; 257 pages, 6 x 9 in. Published by the Ronald Press Co., 15 East 26 St., New York 10, N. Y., $12.*

Much progress has been made since 1936 in the production of electrolytic manganese and in the development of its uses. The first practical method for producing electrolytic manganese was developed at this date under the author's direction at the Bureau of Mines. This book covers the production of electrolytic manganese, the

properties and uses of alloys in which manganese is a necessary component, and alloys in which electrolytic manganese produces significantly different properties than would other types of manganese. Much of the material is drawn from published reports of the Bureau of Mines, to which has been added a substantial amount of hitherto unpublished material from the author's own laboratory work. Reference has been made to practically all the work which has been done in the field.

The result is a comprehensive working reference volume bringing together information on a process which can well make manganese an important contributor to our domestic mineral economy and security. The book should prove useful to mining, metallurgical, and chemical engineers, to makers, fabricators, and users of light metal alloys, to electroplaters and to power engineers.

## Electro-plating, 6th Edition

SAMUEL FIELD, *A.R.C.Sc. City and Guilds of London Institute, and* A. DUDLEY WEILL, *Technical Director, Grauer and Weil, Ltd., London.* 546 *pages,* 5 x 7½ *in. Published* 1951 *by Pitman Publishing Corp.,* 2 *W.* 45*th St., New York* 19, *N. Y.* $6

This book is a survey of modern electrodeposition methods being used in United States and in England. It is the latest edition of a series, the first published in 1930, and covers advances made in electro-plating technique during the last 10 years.

Chapters I through VII comprise a detailed discussion of the fundamental chemical, metallurgical and electrical principles of electro-plating. Chapter I is a review of basic chemistry. It has several appropriate charts including a three page coverage of standard compounds listed with their common names.

Mechanical and chemical cleaning of parts before and after plating is covered in Chapters IX and X and Chapter XI is on electrolytic polishing.

From Chapter XII through XXI electro-chemical characteristics and methods of use relative to the fellow plating material are individually presented: copper (acid bath); copper (Alkaline bath); silver; gold; nickel; zinc; chromium; iron; steel; tin; lead and rare metals. Chapter XXII presents advances gained in recent years toward practical methods of using electro-deposits to enhance the corrosion resistant qualities of aluminum and magnesium. Deposition of brass, bronze, speculum metal and other al-

FOR RESISTANCE TYPE WELDERS • FOR AIR CLAMPS • FOR AUTOMATION • FOR LATHE CHUCKS • FOR AIR VISES • FOR MACHINE FEEDS • FOR PRESS BRAKES • FOR STEEL MILL EQUIPMENT

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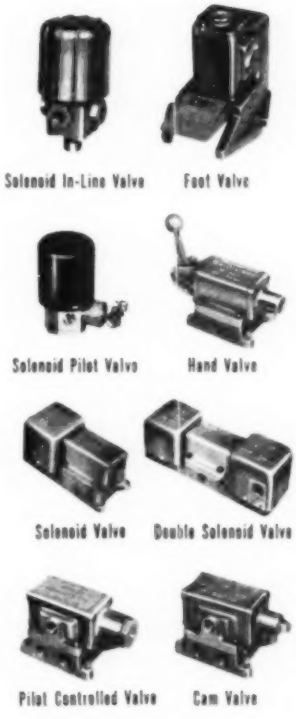


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**EFFICIENT!** Full flow design . . . plus simplified construction with only one moving part . . . add up to more dependable performance, longer life, reduced maintenance.

**COMPACT!** The compact design of MAC valves makes them especially adaptable for installations where space is limited.

**ECONOMICAL!** Yes . . . with all their extra advantages, MAC valves are actually priced *lower* than many ordinary air valves. Here's an investment that really pays off!

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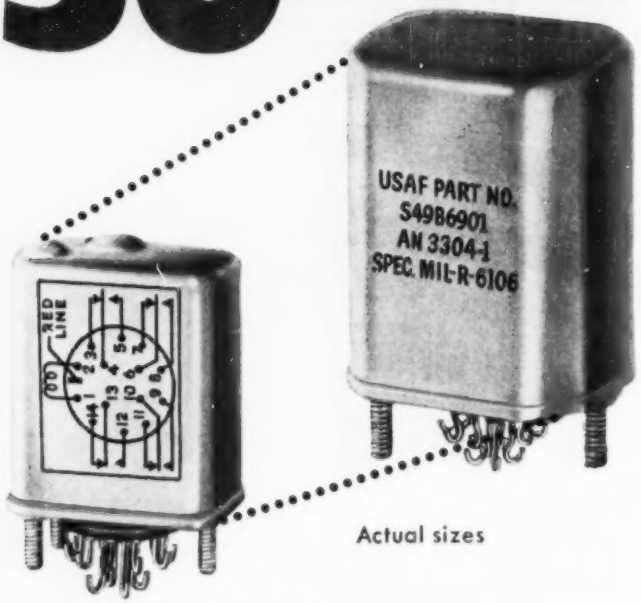



Actual sizes

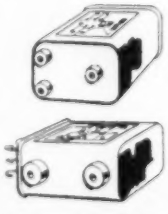
## R-B-M 22300 SERIES

## Hermetically Sealed Relays

The R-B-M 22300 hermetically sealed telephone type relay is the electrical and mechanical equivalent of AN 3304-1, except for smaller size and mounting dimensions.

An improved armature design, plus high temperature molded nylon coil bobbin, provides greatly improved magnetic efficiency and enables R-B-M to reduce the overall size of the relay. The R-B-M 22300 design still retains palladium cross-bar contacts identical to those used in the larger size.

Maximum contacts—6 Form A and 4 Form C-3 ampere 28 Volts. D. C. coil construction only. Maximum coil resistance 5000 ohms. Minimum power .75 watts. Also available in AN 3304 can for dynamotor or low capacitance application.



Optional Mounting Arrangements

Write Dept. C-5 for ASR Bulletin.

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*Logansport, Indiana*

MANUAL AND MAGNETIC ELECTRIC CONTROLS
—FOR AUTOMOTIVE, INDUSTRIAL, COMMUNICATION AND ELECTRONIC USE




loys is explained in Chapter XXI Chapter XXIV describes the vario methods of testing electrodeposits a Chapter XXV covers processes alli with conventional electroplating su as detachable deposits, metallizin Parkerizing and bonderizing. Chapt XXVI is on metal coloring and is fo lowed by an appendix of miscellanco information pertinent to the vario fields of electro-plating operations.

### Typical Microstructures Of Cast Iron

*Published by British Cast Iron R search Association, Alvechurch, Bi mingham, England.* 54 *pp.* $2.10 *t members,* $2.94 *to non-members.*

This book is intended for foundry metallurgists, engineers, and any user of cast iron required to evaluate microstructure against specified property requirements. It provides, for reference and comparison, a series of photomicrographs of the principle types of cast iron normally encountered.

A technical introduction explains the dependence of structure and properties of cast iron on cooling rate and composition. It considers separately the mode of occurrance and appearance of the various constituents of cast iron.

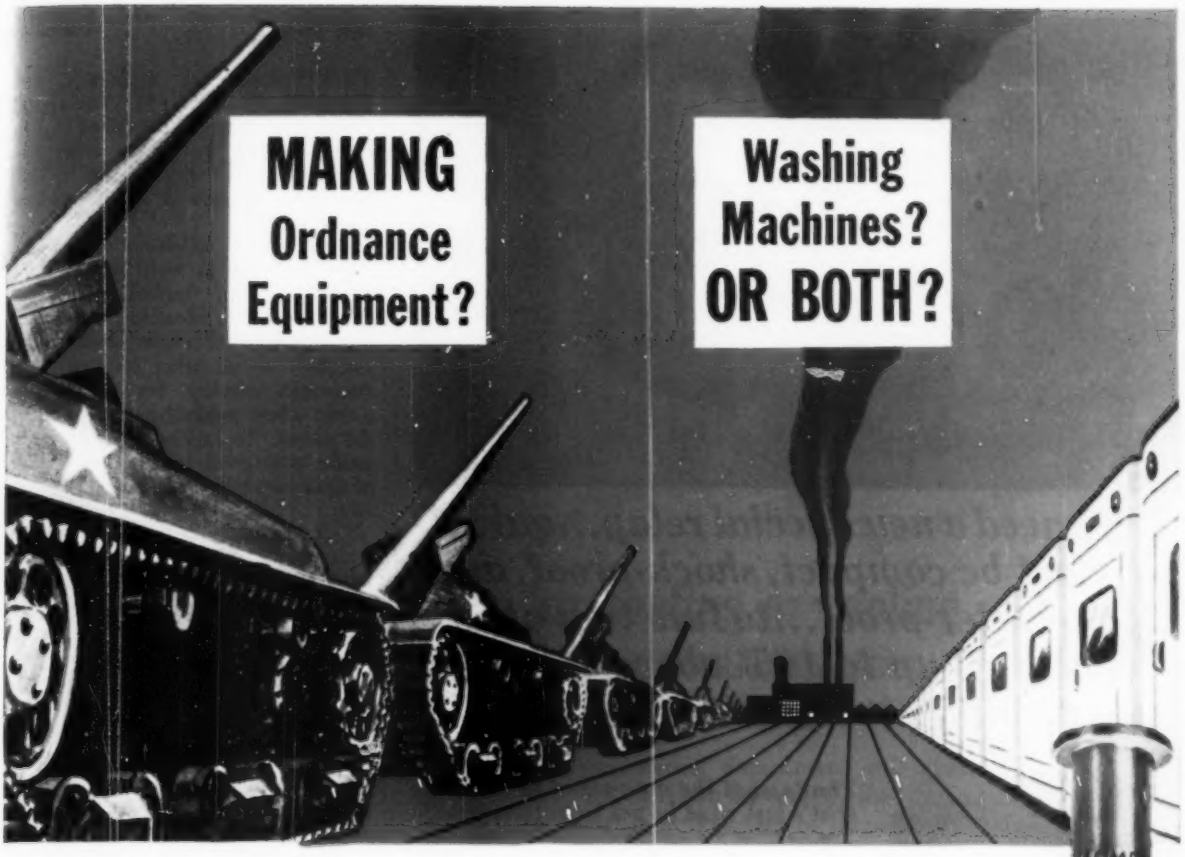
The forty-one photomicrographs included in this volume are accompanied in each case by an explanatory text on the facing page. They are arranged in three main sections. The first deals with the principle constituents occurring in cast iron. The second depicts the structures of typical unalloyed and alloyed cast irons, including malleable cast iron. The final section illustrates some typical defects experienced in iron castings used in the industries.

### Treatise on Powder Metallurgy, Vol. III

CLAUS G. GOETZEL, *Vice President and Director of Research, Sintercast Corp. of America, Adjunct Prof. of Chemical Eng., N. Y. Univ.* 899 *pages,* 6 x 9 *in. Published by Interscience Publishers, Inc. New York, N. Y.* $22.

This, the last of three volumes on powdered metallurgy, is a classified and annotated bibliography. It consists of two parts.

Part I is a literature survey. References are divided into the following categories (1) Powder Metallurgy, General; (2) Production and Composition of Powders; (3) Powder Processing Methods and Equipment; (4) Powder Metallurgy, Products,

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***That's what the man asked for...*** and that's just what he got from Riverside. Yes, within the specified time, Riverside engineers had designed a product to meet those tough specifications . . . and Riverside's complete, versatile production facilities had turned out sufficient quantities to fill initial delivery requirements. The relays were tested and approved . . . used immediately to break a serious bottleneck that had stopped the customer's production.

You might think that's an unusual "case history." But actually it's typical of the way things get done at Riverside. Yet service is only one of the reasons why Riverside has become a leading producer of wiring harnesses, devices, and assemblies. Cost and quality are the other important factors. And, chances are, our specialized engineering and manufacturing facilities can quickly find a way to make *your* electrical components better for less, too. Why not send us your specifications, prints, or samples for prompt recommendations and quotations. No charge . . . no obligation, of course.

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Their Composition, Properties, and Manufacture; and (5) Theoretical Discourses. Material published in Britain, Germany, Russia and other foreign countries are included besides that which has originated in the United States.

Part II is a collection of patents. Again, foreign as well as American contributors are included. In the American patent notations, the inventor is given, and where possible, the assignee. In all other countries, the companies owning the patent are named where published at the head of the patent. To facilitate searching the patent date given in all cases is that of issue rather than of filing.

## Electrical Engineering—Volume I, Direct Currents, Fourth Edition

CHESTER L. DAWES, *Associate Professor, Harvard University, 736 pp, 6 x 9 in. Published by McGraw-Hill Book Co., Inc., 330 W. 42 St., New York 36, N. Y.*, $7.00.

College textbooks are frequently used by practicing engineers for reference or review. Generally, the subject matter in textbooks is presented in great detail and is arranged so that the reader can absorb it as easily as possible. Electrical Engineering can serve as a reference or for the self-instruction of those engineers who had a minimum of electrical courses in their schooling.

This new edition provides the student who is beginning the subject of electrical engineering with a course which includes both theory and practice in the field of direct currents. In general, the book covers electrical circuits and circuit theory, primary and secondary batteries, electrical instruments, and measurements, magnetism, electrostatics and the dielectric circuit, electrical machinery and direct-current power transmission. Each subject is developed from elementary, fundamental relations and carried to a level which is sufficiently advanced for most undergraduate curricula.

Throughout the text emphasis is placed on mathematical and theoretical treatment of each subject and each development is illustrated by a numerical example. In order to assist the student in understanding and retaining the theories which are developed, the numerical examples are applied to actual electrical apparatus. The construction of modern electrical apparatus is illustrated with drawings and photographs supplied by leading

manufacturers. In addition, methods for conducting laboratory work are described for both measurements and machinery. These include electrical connections, and methods of obtaining data and computing results.

The new text is now completely up to date, including recent developments in applied electrical science which will give the student a thorough understanding of basic analyses of electric, magnetic, and physical phenomena.

## Selling to Industry

BERNARD LESTER, *Consulting Management Engineer*, 255 *pp*, 4½ x 6⅞ *in. Published by the Industrial Press*, 148 *Lafayette St., New York* 13, *N. Y.*, $3.50.

This book is a manual of practical ideas and suggestions for the sales engineer who wants to analyze and improve his methods of finding, contacting, selling, and servicing industrial customers. The author claims that selling any prospect effectively does not necessarily follow a beaten path. Prospects and salesmen vary in temperament, habits, and interests. The products sold differ, and there are always new problems in their application. Therefore, proper preparation, and orderly procedure are necessary. The author gives the key points, which he has found, from experience, to be most effective.

The book is written in short articles, and grouped in a series of sections entitled: Prospects are Our Market; Just How Do Prospects Buy; Sales Program Essentials; Make the Sales Program Effective; Successful Sales Interviews; Sell the Prospect's Employees; Be a Better Equipment Salesman; Getting Help From Others; Use all Our Sales Tools; Meet the Prospect's Objections; Followup the Customer's Decision; Grow in Power and Sales Skill; and When Orders Hang on Trees. The author writes well.

## The Welding of Non-Ferrous Metals

E. G. WEST. 553 *pages. Published by John Wiley & Sons, Inc.*, 440 *Fourth Ave. New York, N. Y.* $8.50.

The purpose of this book is to place on record basic information on the application of the various welding processes, to the non-ferrous metals. The book has been written with two main classes of reader in view; the welding engineer, operator, instructor and trainee on the one hand and the

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designer, works engineer and metallurgist on the other. There is no attempt to describe in detail all the various welding processes. Brief descriptions of processes and equipment are included, however, to assist the reader who might be new to welding.

Fusion welding, resistance welding and pressure welding are discussed. Separate chapters are alloted to aluminum, copper, nickel, lead, zinc and their alloys. Also covered are the low melting point metals, high melting point metals and the precious metals.

The author writes as a metallurgical authority and each section reveals its metallurgical foundation; but the book successfully informs those who wish to weld in practice and the metallurgy of the matter does not interfere unduly. In addition to the information on how welding is done there is included information on why it is done. The reasons for doing things are not flaunted in the face of the reader but nevertheless constitute the foundation of the book. Coverage is complete.

## Copyright, Design and Patent Guide

HENRY J. E. METZLER, *LLB, Registered Patent Attorney,* 125 *pages,* 5¾ x 8½ *in. Published by Ameliorant Co., Inc., Halesite, N. Y.* $2.

The basic principles of the present copyright and patent laws are outlined and discussed to aid authors, inventors, businessmen and artists in distinguishing between the different types of protection available, namely whether patent, copyright or design protection is best suited for a specific work, article or the like. If it is written clearly and concisely. A comprehensive index is included to help the reader find any of the various topics discussed.

## General Metals

JOHN L. FEIRER. 257 *pages. Published by McGraw-Hill Publishing Co., Inc.,* 330 *W. 42nd St., New York* 36, *N. Y.* $3.

This is the first book in the *McGraw-Hill Publications in Industrial Arts series.* It was written to fill the needs of a modern industrial arts program in general metals. It gives students broad, basic experience in the fundamentals of metalwork and the related information needed to make them more intelligent producers and consumers of metal products.

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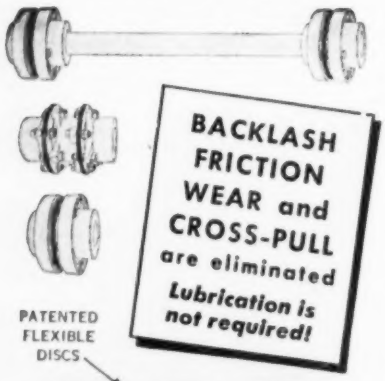


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bench metal, sheet metal, art metal and jewelry, forging, heat treating, foundry, welding, machine shop and metals and metal products. An introduction discusses elementary shop processes and a final section presents suggested projects.

Each of the 62 unit discussions deals with a basic operation, gives instructions on how to perform it and presents related information on equipment, tools, materials and occupational opportunities. The instructive qualities of the book are enhanced by appealing design, well chosen illustrations and helpful discussion questions. This volume is suitable for a general metal shop for the various high school and college industrial arts courses and for workshop purposes.

## Factory Planning And Plant Layout

WILLIAM GRANT IRESON, *Acting Professor of Industrial Engineering, Stanford University.* 385 *pages,* 5½ x 8½ *in. Published by Prentice-Hall, Inc.,* 70 *Fifth Ave., New York* 11, *N. Y.* $7.35.

The ultimate aim of this book is to present factory planning as just what it is: An engineering problem that can be solved by the systematic collection of data, logical analysis of the data, and the application of imagination and initiative.

The final measure of the effectiveness of a factory plan lies in the cost of manufacturing the product in the plant. Cost, then, must be one of the measures that are applied at every step in the procedure. Considerable stress has been placed upon the necessity of considering all possible alternatives that might be selected and the effects of each alternative on the costs of operation. The choice of that set of alternatives which will minimize the cost of production is a problem in engineering economy, and Chapter 3 has been devoted to this subject in order to equip the reader with the proper tools for analyzing the cost aspects of the several alternatives.

Great emphasis has been placed upon obtaining all of the facts and basing decisions upon the analysis of these facts. Hunches, vague notions, and preconceived ideas as bases for decisions should be eliminated in factory planning as well as in all other areas of industrial management. The engineering approach to the problem of factory planning dictates that the problem or objective be determined, that the facts be obtained and recorded in a logical and methodical way, and

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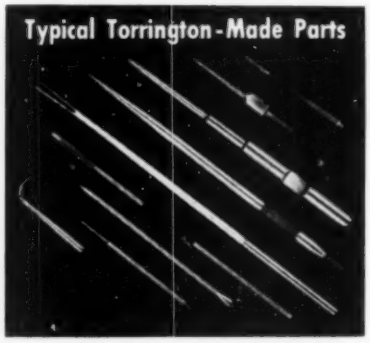


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that the conclusions be drawn by careful weighing of all of the facts without being influenced by personal prejudices. This basic procedure is recommended repeatedly in this book as the proper approach to each phase of factory planning.

Small and medium size plants have been used in the illustrations and problems so that the reader can grasp the over-all aspects of the problem. The problem of planning a factory, or series of factories, for a large and complicated product, such as an automobile, actually consists of a number of smaller problems of planning facilities for production of component parts and sub-assemblies and final assembly lines. Each of these smaller problems will embrace all of the usual phases of factory planning. Such a large factory is not planned in one bold move. It is planned in parts, with each part presenting a problem of manageable size. Thus, the procedures presented there are as simple and direct as possible, involving a minimum of forms, charts and drawings, yet are equally applicable to the planning of manufacturing facilities of any magnitude.

Factory planning is a changing field. Developments in building practices, machine design, materials-handling equipment, raw material and production processes are occurring so rapidly that it is almost impossible to present factual data that will be applicable or accurate for even a few years. Thus, factual data that are subject to change have been kept to a minimum, in the belief that it will be essential for each planning engineer to obtain the data to suit his own problem and conditions. Instead, emphasis has been placed on methods, and illustrations have been used to stimulate ideas and originality. The successful planner will not be bound by tradition and past practices. He will depend upon his knowledge of previous practices for a starting point but will search for new ideas.

## The Technique of Clear Writing

ROBERT GUNNING, 289 *pages*, 5½ x 8 *in. Published by McGraw-Hill Book Co., 330 W. 42nd St., New York 36, N. Y.* $3.50.

The emphasis is on readability in this latest of the how-to-write-clearly books. The author is a readability counselor, and his formula for clear writing is based on widespread reader research. His principles can be summed up in a writer's Golden Rule —"Write unto others as you would be written to."

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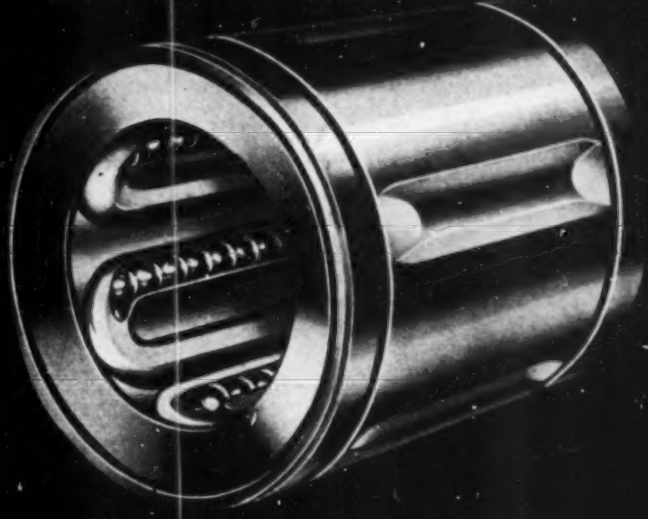

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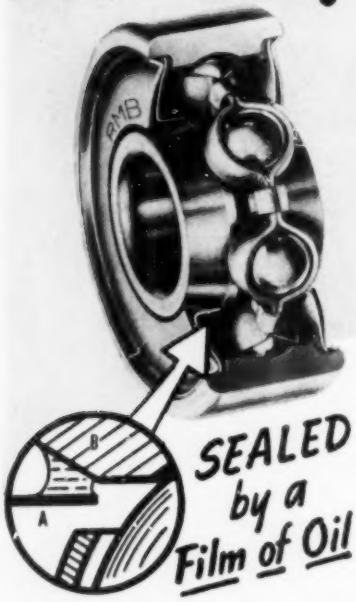


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work—letters, reports, memorandums, technical articles, etc.—can benefit from the material in this book. Mr. Gunning first gives his reader a yardstick to check written material. His "fog index" is more easily obtained than the better known formulas of Rudolf Flesch, Edgar Dale and others. Based on average sentence length and number of words with more than three syllables, the fog index warns the writer that he is turning out confusing and complicated wordage.

Ten Basic principles are offered to the writer as a guide to better writing. The author warns that these are not rules to make writing automatic, merely principles to be applied with thought.

1. Keep sentences short. Average sentence length should be about twenty words. The author stresses the word average in this principle, because there is nothing wrong with well written sentences that use 50 or 60 words as long as they are varied with short sentences. As an example, the author cities a typical page from Thomas Wolfe's "You Can't Go Home Again". There are 91 words in one sentence —but the average length of all sentences on that page is only 22 words.

2. Prefer the simple to the complex. This principle is really made up of five preferences: Prefer the familiar word to the far-fetched, prefer the concrete word to the abstract, prefer the single word to circumlocution, prefer the short word to the long, prefer the Saxon word to the Romance.

3. Use the familiar word. There are about half a million words in the dictionary, but the average person knows only between 10,000 and 30,000. To be understood the writer must use words the reader knows. Big men use little words; little men use big words.

4. Avoid unnecessary words. Tossing out words that say nothing and dropping the mock-legal tone makes a piece of writing quicker to read, easier to read and easier to understand. People who write the same thing twice usually are not clear in their own minds as to what they want to say.

5. Put action in your verbs. Strong verbs give writing bounce and hold a reader's attention.

6. Write as you talk. You can't write exactly what you might say because most people talk rather untidy English. But a bushed-up spoken version is usually easier reading.

7. Use picturable terms. The short simple words usually stand for things the reader can see and touch. Abstract words require additional words to get and idea to the reader.

8. Tie in with the reader's experi-

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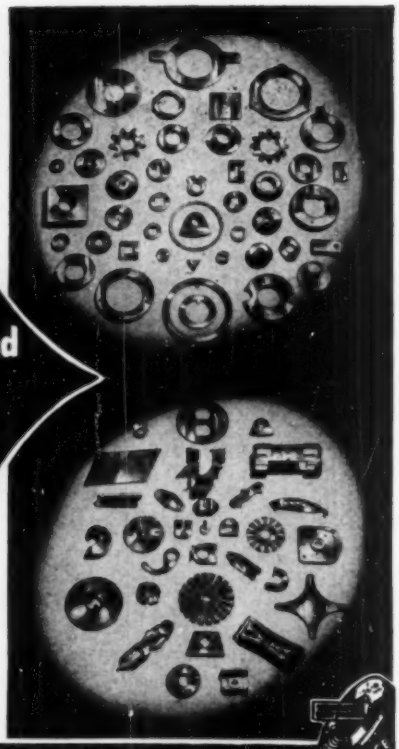

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ence. The writer must understand his reader if he is to make him believe, remember, or act upon what is written.

9. Make full use of variety. Use short sentences and long sentences; use simple, compound and complex sentences.

10. Write to express, not to impress. Writers often confuse formality with elegance and long words. They use the latter as a sign of deep thought. Instead of impressing, they confuse the reader.

Two appendices to the Technique of Clear Writing are particularly valuable for those who want to remove confusion from their writing. One is a listing of 3000 familiar words. The second is a list of short picturable substitutes for long abstract words.

## Tractors and Their Power Units

E. L. BARGER, *Mgr. of Farm Practice Research, Harry Ferguson, Inc.;* W. M. CARLETON, *Assoc. Prof. of Agr. Eng. Michigan State College;* E. G. McKIBBEN, *Principal Agr. Eng., USPA Tillage Machinery Lab.; and* ROY BAINER, *Prof. and Chairman, Div. of Agr. Eng., University of Calif.* 496 *pages;* 6 x 9 *in. Published by John Wiley & Sons, Inc.,* 440 *Fourth Ave., New York* 16, *N. Y.* $6.50.

This is intended as a suitable text for teaching courses on tractors and their power units to students in professional agricultural engineering courses. It may also serve as a useful reference for the practicing engineer in the farm equipment industry and allied fields.

Considerable space is devoted to the internal combustion engine and its accessories as applicable to tractors. Carburetion, fuel injection and combustion are also discussed in detail as are tractor chassis, traction, stability and hitches. Fully illustrated.

## New Lessons in Arc Welding

312 *pp. The Lincoln Electric Welding Company, Cleveland, Ohio.* $1.

The objective of this book is to present in a concise manner certain fundamental facts of welding to enable the welder to use the welding process successfully and economically. The book resulted from an enlargement, by the addition of new material, of a series of lessons that forms the basis of instruction at the Lincoln Arc Welding School. There are 59 lessons included in this book. These consist of two types—the basic course

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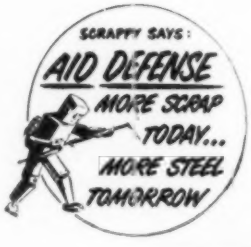


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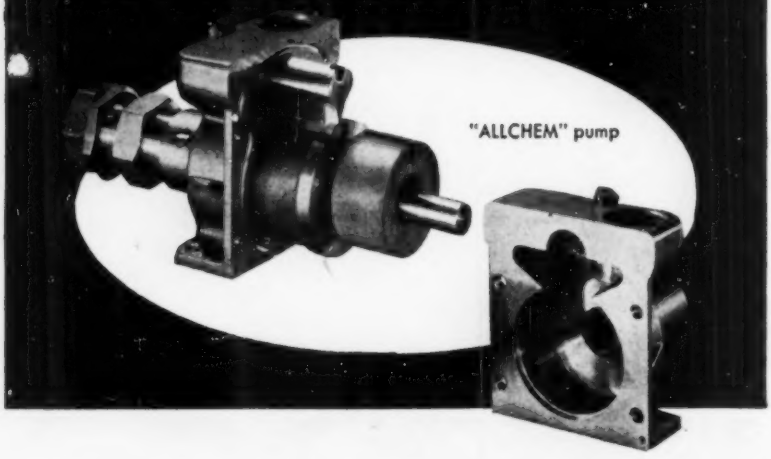


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in the fundamentals of arc welding and the advanced courses in alloy welding, sheet metal welding and pipe welding. The basic course is devoted entirely to the welding of mild steel in all positions. Questions and answers on each lesson are included.

A welding application supplement contained in this volume provides suggestions for further study of the science and practice of arc welding. The supplement is divided into three sections. Section I explains a method of reducing welding costs through the control of welding procedures. Section II covers subjects related to welding, such as weld strength, identification and use of metals. Section III gives some practical ideas for simplifying, by welding, the fabrication of common machine parts. These sections are fully illustrated by sketches and diagrams to clarify the instructions.

### Practical Industrial Electronics

F. A. ANNETT, *Associate Editor, Power Magazine,* 381 *pp,* 6 x 9 *in. Published by McGraw-Hill Book Co.,* 330 *W. 42 St., New York* 36, *N. Y.* $5.50.

Here is a book written expressly for the many operating engineers and electricians now confronted with jobs in the installation, operation, and maintenance of electronic equipment, and having little previous training in the subject. To them it gives the plainest sort of description of the field, covering the electron itself, the various tubes, the fundamental circuits, and the more complex circuits and performance of many different control devices.

It describes such devices as electronic heating-system controls, automatic systems of electronic combustion control, magnetic drive-speed control, motor-generator exciters, liquid-level and pump controls. It clearly discusses the application, circuits, and operation of rectifiers, relays, oscillators, smoke indicators and recorders, combustion safe-guards, motor-speed controllers, etc.

Electrical fundamentals and elementary circuits are treated in separate chapters. With these and the plainly explanatory treatment throughout, the book makes electronics a simple, useful thing instead of a mystery.

The book grew from a series of widely acclaimed articles first published in *Power.* As presented here, the treatment grounds the engineer and electrician in the fundamentals—provides aid in working with electronic devices encountered in industry.